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THESIS

BATTLEFIELD MAINTENANCE AND RECOVERY MODULE
FOR THE AIRLAND RESEARCH MODEL

by

Arild W. Olsen

March 1986

Thesis Advisor:

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Battlefield Maintenance and Recovery Module
for the Airland Research Model

by

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Submitted in partial fulfillment of the
requirements for the degree of

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March 1986

ABSTRACT

This thesis describes a battlefield maintenance and recovery model which will be used in conjunction with the Airland Research Model being developed at the Naval Postgraduate School. It was developed focusing on the two main levels of maintenance in an Army division. These are the organizational level and the direct support level. Its main area of emphasis is to determine the impact maintenance and recovery have on the combat value of a unit. It investigates the difference in two maintenance concepts. The first one being recover and return to the rear area for repair and the second being fix forward.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to develop a battlefield maintenance and recovery module (MRM) for inclusion in the Airland Research Model (ALARM). This module will be developed focusing on the two major levels of maintenance support on the battlefield; organizational maintenance and direct support maintenance. It will enable the Airland Research model to assess the impact on combat battlefield maintenance and recovery. Currently there are two different methodologies being considered. The first is the concept of fix forward; the second being recover and repair in the rear area.

1. Recovery and Evacuation

Battlefield recovery and evacuation can be a manpower intensive, time consuming endeavor. Current modelling methodologies rarely consider this as one of the variables involved in returning a disabled piece of equipment to the battlefield. Recovery is primarily the removal of a damaged piece of equipment from the battlefield by an external source to an area where it can be repaired. This external source can be either a like vehicle or a recovery vehicle such as a heavy equipment transporter (HET). The area where it can be repaired is usually the unit field trains which consist of the logistics personnel of the battalion. This would include the supply and maintenance personnel on the organization level.

Evacuation is the transfer of a disabled piece of equipment to a higher maintenance echelon. This is usually the transfer of equipment from the organizational to the direct support level of maintenance. Regardless of whether a unit is performing recovery or evacuation it requires a

large number of personnel and recovery assets for an extended period of time. In a scenario such as the European environment, the time factor will be critical when we are fighting outnumbered. Therefore what is needed is a way to assess the combat value of a maintenance program which utilizes the fix forward concept as much as possible versus the combat value of a program which recovers and repairs in the rear.

2. Fix Forward

The fix forward concept entails attaching a maintenance support team of five to twenty mechanics, depending on the size and mission of the supported battalion. It will also include an initial stockage of repair parts dependent on the density of equipment types which the battalion possesses. The advantage of this maintenance concept is that it allows the mechanics to be where the equipment is and to repair it where it is damaged. This relieves both the supported battalion and the supporting maintenance company of the problem of having to recover the equipment in order to get it repaired. The disadvantage of this concept is that it will divide the supporting maintenance company assets into four or five segments, depending on the number of battalions they are supporting, thus increasing the amount of command and control necessary to insure the effective and efficient operation of all elements. It will also split the stockage of repair parts and make it more difficult to insure the parts are located where they are needed.

3. Recover and Repair

The concept of recover and repair has been the mainstay of current maintenance doctrine. In this concept all damaged equipment is recovered or evacuated from the battlefield and taken to the appropriate maintenance facility for repair. The advantage of this concept is that all mechanics and repair parts are centrally located so that there is no

possibility of one unit having a surplus of maintenance capability and another having a shortfall. All assets are under the direct command and control of the maintenance company commander and are responsive to any change in the tactical situation. The primary disadvantage of this concept is that it requires the additional time to recover equipment and then to return the equipment after repair. Also it requires additional personnel and recovery assets that may not be necessary if maintenance assets were available on site.

4. Objectives of Research

Research for the MRM considered different modelling methodologies for its development. The objectives of the research for the MRM are as follows.

- a) Determine levels and methods for aggregation and/or disaggregation.
- b) Obtain a data base for the MRM.
- c) Integrate maintenance and recovery into the transportation network methodology.
- d) Build a simulation model of battlefield maintenance and recovery.

B. MAINTENANCE SUPPORT OVERVIEW

1. Maintenance Definition

Maintenance as defined by FM 100-10 (Combat Service Support) consists of all actions taken to retain material in a serviceable condition or to restore it to serviceability. Doctrine has indicated that in the Airland Battle U.S. forces will be fighting outnumbered. Thus it is imperative that we recover and return to serviceability all damaged and disabled equipment as soon as possible. The concept of "fix forward" needs to be integrated into the total maintenance picture. This concept will help to maximize weapons system combat time by reducing or eliminating the time required for recovery and evacuation. Battlefield recovery and evacuation is defined as the process of retrieving

inoperable or battle damaged equipment from forward areas to the supporting maintenance activity for repair (either unit field trains or a supporting direct support maintenance activity). Utilization of a fix forward concept would require the commitment of a substantial amount of maintenance capability (mechanics and repair parts) in the actual battle area.

2. Returning Disabled Equipment to Serviceability

Returning a disabled or battle damaged piece of equipment to serviceability normally requires two interdependent actions to take place. These are a maintenance action, which entails personnel and equipment, and a supply action.

The maintenance action can be divided into various subtasks such as:

- a) Inspection and classification of equipment
- b) Repair of equipment
- c) Testing of repaired equipment

The supply action can also be divided into various subtasks such as:

- a) Receipt, storage and issue of repair parts
- b) Direct exchange
- c) Operational readiness float (ORF)
- d) Controlled exchange and cannibilization

All of these tasks are interrelated in one way or another and cannot function alone on a battlefield.

3. Inspection and Classification

The inspection and classification of a disabled piece of equipment is done in order to accurately ascertain the extent of damage and the repairability of the equipment. The initial assessment is done by the owning unit's organizational mechanics. They will determine if the equipment can be repaired at their level with the repair parts and skill levels they possess. If the mechanics determine that they do

not have the capability to repair the item, they will contact their supporting direct support maintenance company for a formal inspection and classification. This entails a formal procedure by which the inspector determines the extent of damage and the repair parts required to restore it to serviceability. If the damage is extensive the inspector will then determine if the equipment is economically or uneconomically repairable. If it is determined to be uneconomically repairable, it is then removed from the inventory of the owning unit and placed in a cannibilization status where any serviceable components can be removed.

4. Repair of Equipment

After the extent of damage has been determined and the appropriate repair parts have been obtained, a crew of mechanics will repair or replace components of the damaged equipment according to the inspection sheet. The type of mechanic utilized for the repairs depends on the system or components damaged. The number of mechanics used also depends on the component damaged.

5. Testing of Repaired Equipment

Upon completion of repairs by the maintenance crew the piece of equipment is returned to the inspection section. There it is determined if the correct repairs were made and whether the equipment has been returned to a serviceable condition. When this has been determined, the supporting maintenance unit will notify the owning unit to pick up the equipment.

6. Receipt, Storage and Issue of Repair Parts

The receipt, storage and issue of repair parts is one of the most critical functions of a maintenance unit. If the correct repair parts are not on-hand or if they cannot be obtained in an expedient manner, the maintenance unit cannot repair damaged equipment. Each company in the Army has a prescribed load list (PLL) of repair parts. This list

depends on the type of equipment a unit has and on the densities of this equipment. It is a listing of those repair parts required to be on-hand by the unit in order to sustain it in a combat situation for thirty days and is determined through historical records of the equipment on-hand and their consumption of repair parts.

At the direct support level of maintenance the combat divisions have an authorized stockage list (ASL) which is a listing of repair parts and major assemblies required to be on-hand. The major assemblies are engines, transmissions, transfers, axles, final drives, etc. The division ASL supplies all the repair parts for the entire division. It is used to replenish the PLL of individual companies and forms a basis for the direct support stockage of repair parts for the division maintenance battalion. The division ASL is maintained by the divisional maintenance battalion in a central warehouse. Each line item of stockage is tracked to insure that there are always supplies on-hand. As an item is ordered from the warehouse it is annotated as in a checking account. When the balance of the item on-hand reaches the reorder point, a requisition is sent to the next higher stockage point to replenish it to its authorized level. These stockage levels and reorder points are computed to allow the division an average thirty day stockage of repair parts.

7. Direct Exchange

The direct exchange (DX) system is used to augment the division's ASL and the company's PLL. It consists of those repair parts that can in themselves be repaired rather than just replaced. These items consist of things such as generators, alternators, carburetors, fuel injection pumps, etc. They are requisitioned the same as repair parts, except that the damaged item must be turned in for repair.

8. Operational Readiness Float

The operational readiness float (ORF) of a division consists of a collection of major end items: tanks, trucks, armored personnel carriers, etc. They are utilized only as a wartime stockage reserve. If a damaged piece of equipment is determined to be uneconomically repairable and removed from the owning unit's inventory it will be replaced by a like item from the division float assets. A new end item will be requisitioned and when received will be placed in the float. This is done primarily so that a unit will not be short any equipment which will degrade its combat effectiveness.

9. Controlled Exchange and Cannibalization

Controlled exchange and cannibalization are a last resort for obtaining repair parts. Cannibalization is the removal of serviceable repair parts from an uneconomically repairable item of equipment. Controlled exchange is the removal of serviceable repair parts from a like piece of equipment that is disabled for another reason, which results in getting one item in a combat ready posture at the expense of another. Both of these are actions of last resort because they entail doubling the workload of repairing an item.

C. MAINTENANCE ECHELONS

1. Echelon Definition

The U.S. Army currently uses a system of four maintenance echelons. These levels of maintenance are:

- a) Organizational (operator and unit)
- b) Direct Support
- c) General Support
- d) Depot

Proposals for doctrinal changes in maintenance support as specified in the Airland Battle 2000 concept would reduce the number of maintenance echelons to two. The proposal is to combine organizational and direct support as

one echelon, and general support and depot repair as the second echelon. Since the Airland Research Model is structured at a corps level, the two primary levels of maintenance support which will be utilized in the maintenance module will be the organizational level and the direct support level.

2. Responsibilities

The organizational level of maintenance is characterized by preventive maintenance and replacement of direct exchange type repair parts, i.e., carburetors, distributors, tires, etc. In a combat situation these actions would be limited to mission essential maintenance only (MEMO) which is defined as only that maintenance required to keep a vehicle operationally ready for a given mission.

The direct support level of maintenance is characterized by the replacement of major components of weapon systems, i.e., engines, transmissions, final drives, tank tubes, fire control equipment, etc., the evacuation of damaged equipment to higher levels of support, backup recovery support and repair parts supply.

D. PROBLEM DEFINITION

What is needed is a prescriptive model which will explicitly simulate battlefield maintenance and recovery. There are two models which are currently being utilized to simulate combat service support operations in a combat environment. These are the ARMY UNIT READINESS/SUSTAINABILITY ASSESSOR (AURA) Model and the combat service support module in the FORCE COMBAT EVALUATION MODEL (FORCEM). Maintenance support in both these models are explicit, sequential event type models. These two models differ greatly in their degree of resolution in simulating battlefield maintenance and recovery. AURA is a very high resolution model while FORCEM is a low resolution model.

FORCEM is a theater level combat model. Its simulation of maintenance and recovery is one of low resolution. It is a deterministic model and uses expected value data. The maintenance routines in this model are called only once every 24 hours of simulation time. It is considered a low resolution model for maintenance and recovery for several reasons:

- a) Representation of equipment
- b) Representation of personnel
- c) Representation of repair, repair parts and repair parts supply
- d) Maintenance asset attrition

The representation of equipment in FORCEM assumes that all vehicles will fall into a general vehicle class. For example, all trucks two and a half tons and heavier will be represented as similar vehicles utilizing the same mechanics and repair parts. The representation of personnel in FORCEM assumes that all maintenance personnel possess all requisite skills to complete any maintenance task. Repair parts are represented by tonnage, i.e., a certain vehicle class will require a specified tonnage of repair parts, and in order for the vehicles to be repaired, that many tons of repair parts must be available. The final assumption is that maintenance asset attrition can occur only at their base location, which means they are invulnerable when performing recovery missions or when support elements are fixing forward.

According to the AURA users manual, "AURA is a Monte Carlo discrete event simulation model intended for analyzing the interrelationships among the resources associated with a set of combat units, and the capabilities of those units to generate combat missions in a dynamic and rapidly evolving wartime environment." It is a very high resolution model which simulates vehicle maintenance, repair parts supply, support repair jobs and recovery.

In contrast to the FORCEM model it provides for repair parts in terms of the actual parts required, (i.e., normal receipt and issue, direct exchange, cannibalization or controlled exchange). Maintenance personnel are allocated by the particular "shop" in which they work. AURA provides for thirty possible maintenance shops within a maintenance organization. AURA's actual maintenance tasks that can assigned to these shops include:

- 1) Unscheduled maintenance
- 2) Pre-mission tasks
- 3) Battle damage repair tasks
- 4) Other related vehicle tasks (Refueling, rearming, etc)

Each of the sub tasks in these areas can be defined as one-step or multi-step procedures depending on user input. The actual maintenance decision processes are explicitly represented in this model. The majority of the program is user defined inputs or functions such as equipment inventories, repair parts inventories, maintenance skill definition, force structure and maintenance and supply decision doctrine.

These two models explicitly represent the "real world" processes. What is needed for the Airland Research Model is to find a compromise in resolution between these two models that would provide an accurate depiction of maintenance support but without an immense data base. Another goal for the MRM is to develop appropriate stochastic processes and their parameters for combat maintenance support if at all possible. If so, it would provide a prescriptive capability for the Airland Research Model which would represent maintenance support under combat conditions in conjunction with the overall combat model.

This thesis is divided into five chapters and two appendices. Chapter one has provided an introduction and an overview of maintenance support. Chapter two deals with the

module design concepts utilized in the construction of the MRM. Chapter three is an analysis of the combat damage data from the Southeast Asia conflict and the Yom Kippur war. Chapter four is a detailed step through of the decision logic and routines utilized by this model. Chapter five is an analysis of the model output and the resulting conclusions that were formulated. Appendix A is the program listing of the tank maintenance and recovery routines. The other three vehicle routines were omitted for brevity. Appendix B explains the variables utilized in the program.

II. MODULE DESIGN CONCEPTS

A. RESOLUTION

As previously stated, the major concern regarding the inclusion of a maintenance support module into a corps level combat model is what level of resolution is required. Constrained by storage capabilities and computer run time, a module as highly resolved as AURA would not be practical for use in the Airland Research Model. However a low resolution module such as that found in FORCEM would not give an adequate depiction of maintenance support and its impact on the rest of the model.

The resolution of maintenance support can be divided into three areas. The first is the representation of the various types of vehicles present on the battlefield today, secondly is the representation of all the different repair parts that will be utilized by these vehicles, and thirdly the different types of specialized repair personnel that are currently being trained and utilized in the maintenance field must be represented.

1. Vehicle Representation

The resolution required in the representation of vehicles on the battlefield must accurately depict the major combat power and transportation assets of the unit being modeled. It must be detailed enough to represent the major portion of the vehicle assets available to the unit but general enough so that the data base requirements for the repair parts of these vehicles will be minimized.

The resolution that will be used in the MRM for vehicles will be the same as that used in the FORCEM model. The MRM will represent general vehicle classes and will base the repair parts assets and the mechanics required on these different classes. This representation, although very

general, will meet the attributes mentioned above in that it will represent the major portion of the vehicle assets in the unit but will simplify repair parts representation.

2. Repair Parts Representation

The level of resolution in representing repair parts in the MRM will be somewhere between the representations in AURA and FORCEM. It will be more closely related to AURA in that specific repair parts will be represented as opposed to FORCEM which utilizes tonnage of repair parts. The MRM will represent many of the major assemblies that are replaced at the Direct Support level of maintenance i.e., engines and transmissions. It will not go to the level of detail that AURA does in representing direct exchange and controlled substitution. That level of resolution for this model is not desired or required. By representing only the major assemblies as repair parts we capture the majority of those repairs that affect mobility and firepower in a vehicle.

3. Maintenance Personnel Representation

In the MRM the different types of mechanics that will be utilized by a Maintenance Support Team (MST) or a Direct Support maintenance company will be represented. Since the representation of repair parts will be limited to the major assemblies we need only to represent the mechanics that will repair or replace these assemblies. This level of resolution is between the levels of AURA and FORCEM. FORCEM represents only a mechanic who can repair all damages, AURA represents twenty five separate shops and their mechanics which cover almost any type of repair that would be required.

4. Overall Level of Resolution

As mentioned above, the three categories of vehicles, repair parts and mechanics all affect the overall level of resolution of a simulation. These three categories can be multiplicative with respect to each other. An

increase or decrease in one category can affect the magnitude of the other two categories, so that in determining an overall level of resolution all three categories need to be considered together.

B. STRUCTURE

Battlefield maintenance and recovery during a corps level field exercise is a fluid activity rather than a static one. In order to accurately portray maintenance support, it must be an integral and continual part of the combat model.

The MRM will be structured so that it can be run off-line from the main combat model (ALARM). It will then be available for use at any time during the execution of the main model. The Airland Research Model will provide inputs to the MRM. These inputs will be the number of vehicles by category that have been damaged during the course of a battle and their location on the battlefield.

1. Vehicle Categories

There are four categories of vehicles in the initial maintenance module. These categories were selected because they represent the majority of vehicles in the Army inventory and the actual maintenance requirements within each category for different types of vehicles are very similar. For example, the number of mechanics and the amount of time required to repair an engine on a 5 ton versus a 2 1/2 ton truck are the same. The categories selected are:

- a) Tanks
- b) Armored Personnel Carriers
- c) Wheeled vehicles
- d) Artillery pieces

These categories represent the major portion of the combat systems that will be present on the battlefield, and are equally representative of either an armored or an infantry division.

2. Maintenance Entities

The actual maintenance entity in this model will be represented by a mechanic. The mechanic types that are utilized are:

- a) 63C - Tank vehicle mechanic
- b) 63H - Wheeled vehicle mechanic
- c) 45K - Armament mechanic
- d) 45C - Fire control mechanic
- e) 63G - Fuel/electrical mechanic

These military occupational specialties (MOS) were selected for the initial runs of the model because they represent the major portion of a direct support maintenance company and the major portion of an organizational motor pool.

3. Repair Part Categories

The selection of the repair parts to be modeled was based on the vehicle categories selected. These repair parts represent the major assemblies of these vehicles and are the components which most directly affect the mobility and fire-power of the vehicle. Because of the similarity of the components of the tracked vehicles, the categories of tanks, armored personnel carriers and artillery pieces will all utilize the same type of repair parts. These are:

- a) Engine
- b) Transmission
- c) Transfer
- d) Final drive
- e) Track
- f) Fire Control System
- g) Armament System
- h) Electrical System

The wheeled vehicles represented in this model utilize four types of repair parts. These are:

- a) Engine
- b) Transmission
- c) Transfer
- d) Axle/Suspension System

These categories of repair parts for the wheeled and tracked vehicles represent the major portion of those repairs that would be necessary in a combat environment to maintain them in a combat ready status. This representation allows the monitoring of specific repairs and repair parts rather than just tonnages of repair parts as is done in the FORCEM model. It is also not as complex or intensive as the AURA model but allows an accurate portrayal of battlefield maintenance at a level of resolution compatible with the Airland Research Model.

C. PRIORITIZATION

1. Vehicle Type Priority

Standard Army doctrine designates a priority listing for repair work. This listing is based on what the Army defines as 'pacing' items. Pacing items are those major end items which provide the main combat power of a unit. For example, the pacing item for an armored battalion is a tank, for an infantry unit it is an armored personnel carrier, and for an artillery battery it is their howitzers. These three items of equipment would receive priority of repair over all other pieces of equipment within those three types of units. For the purpose of this model, these three pacing items are the only three utilized, however within these three there is also a prioritization. The priority of repair utilized by the model is:

- a) Tank vehicles
- b) Artillery pieces
- c) Armored personnel carriers
- d) Wheeled vehicles

2. Hierarchical Priority

As previously discussed, vehicles within an organization are prioritized for repair work. Concurrently, organizations themselves can be prioritized for repair work. This will work in conjunction with the Generalized Value System. Each element of a division has some value associated with it depending on its mission, its strength, its location on the battlefield and its operational capability. This value can be used as a discriminator in determining priority of repair.

3. Utilization

These priorities will come into play if demand for repair exceeds maintenance capability. If the number of mechanics required exceed the number available, the items requiring repair will go into the appropriate queue. The queues will be prioritized according to vehicle type and unit hierarchy. These queues can then be changed by the user if the situation dictates. This will occur in the hierarchical priority as the value of a unit changes as its mission changes. The prioritization by vehicle can also change if the operational readiness of a specific weapon system drops below a predesignated threshold level. The operational readiness of a vehicle is defined as the number of combat ready vehicles (by type) divided by the total number of vehicles (by type). This will give an availability percentage by vehicle type. This percentage will generally range between 0.50 and 0.70. For example, if the predesignated rate for armored personnel carriers was 0.70 and the operational readiness rate for them was calculated to be 0.60 then priority of repair would be shifted to armored personnel carriers until its readiness rate was above the threshold level.

D. ALLOCATION OF MAINTENANCE SUPPORT TEAMS

Each maneuver battalion and artillery battalion is allocated a direct support maintenance support team (MST) to be deployed forward along with the unit's field trains. Their mission will be to repair those items of equipment that are considered fast turnaround repairs. A fast turnaround repair is defined as any repair job that can be completed within four hours by a crew of two or three mechanics. Fast turnaround repairs will be utilized for those jobs that can be repaired on-site in order to eliminate recovery time. The maintenance support teams will be under the operational control (OPCON) of the supported unit but will receive all class IX (repair parts) direct support supply from their organic maintenance company.

The MST will function independently of the Direct Support maintenance company in the rear and will complete all repairs within their capability. This capability depends on two factors. The first factor is the number of mechanics in each area that the support team has and the second is the repair time criteria mentioned above. As an example, if the MST has ten mechanics available for repair and the repair time criteria is eight hours it equates to a repair capability of eighty manhours. This would then be utilized in determining evacuation criteria for the MST. This criteria is determined based on the desired allowable workload above the repair capability. The evacuation decision may be to evacuate any repair job which would exceed the repair capability of the MST, or it could be set at some multiple of the repair capability. As in the example above, the evacuation criteria could be set at two times the repair capability which would mean all repair work up to 160 manhours of repair would remain at the MST and anything in excess of this would be evacuated to the DS maintenance company in the rear.

E. BATTLE DAMAGE ASSESSMENT

The Airland Research Model (ALARM) will provide the MRM with the number of vehicles, by type, that have been damaged during the course of a battle. The MRM will then take these numbers and assess specific repair requirements for these vehicles. It will first determine how many of the vehicles have been completely destroyed and then determine how many of the damaged vehicles will require engines, transmissions, etc. It will do this through an empirical distribution obtained from actual combat data from the Yom Kippur War and the Southeast Asia conflict. An example of the combat data from these conflicts along with an analysis of that data is provided in Chapter 3.

III. COMBAT DATA ANALYSIS

A. DESCRIPTION OF DATA

The combat data that was utilized in the MRM was obtained from the Combat Data Information Center of the Air Force Wright Aeronautical Laboratory located at Wright-Patterson AFB in Ohio. The data obtained consisted of two separate databases. One was the Southeast Asia Ground Vehicle Database and the other was the Arab-Israeli Conflict (1973) Database (Yom Kippur). These databases were analyzed to determine an empirical distribution of combat damage to be utilized in the maintenance module of the Airland Research Model.

1. Southeast Asia Ground Vehicle Database

This database is a collection of 706 Army ground vehicle reports prepared by a 47-man Battle Damage Assessment and Reporting Team in Southeast Asia. It contains the details of individual combat incidents in which loss or damage occurred. An example of the data is shown in Figure 1.

The types of vehicles analyzed for utilization in the damage distribution of this model were armored personnel carriers, tanks, wheeled vehicles and artillery pieces. The information extracted from the separate incidents include model type, direct and indirect hits, hit location, threat type, repair level and manhours if available, and the systems that were damaged. The types of weapons that were used against this equipment were classified into six categories: mines, rocket propelled grenades, mortar and rockets, machine guns, small arms, and grenades.

2. Arab-Israeli Conflict (1973) Data Base

The database from the 1973 Arab-Israeli conflict was collected by the Weapons Systems Evaluation Group (WSEG) in

MODEL	MATERIAL TYPE	MOD OD	DIR HITS	IND HITS	OPS IMPACT	SYSTEMS DAMAGED
	REPAIR STATUS	REPAIR LVL		REPAIR M/H	HIT LOCATION	
M48	TANK RECOVERED	568 DEPOT	02	00	RENDERED INOPERABLE TRACK	WHEEL SUSPENSION TRACK FRAME
M113	ABANDONED	553	01	00	SCRAPPED HULL	TOTALLY DEST
M113	RECOVERED	553 CONUS	01	00	RENDERED INOPERABLE TRACK	TRACK WHEEL TRANSMISSION SUSPENSION DRIVE TRAIN CUPOLA HULL MAIN ARMAMENT ENGINE FUEL TANK
M113		553	01	00	SCRAPPED HULL	TOTALLY DEST
M113		553	04	00	SCRAPPED HULL/WHEEL/TURRET	TOTALLY DEST
M113	RECOVERED	553 DEPOT	01	00	RENDERED INOPERABLE TRACK	FRAME SUSPENSION DRIVE TRAIN WHEEL

Figure 3.1 Southeast Asia Data Base Example.

conjunction with representatives of the Israeli Defense Force. It consists of a total of 774 reports describing damage to individual vehicles (577 tanks and 197 armored personnel carriers). The information that was extracted from this database consisted of type of vehicle, general hit location, component of initial impact, and component of subsequent impact.

B. TANK DAMAGE DATA

Analysis of the tank data from these two databases produced a total of 257 separate combat incidents in which the vehicle involved was either totally destroyed or one or more of the repair parts or components being modeled were damaged. From these 257 incidents there were a total of 425 separate components damaged. A breakout of the total damages by component is given in Table 1.

TABLE I
TANK DAMAGES BY COMPONENT

1)	Tanks totally destroyed	-	70
2)	Engines damaged	-	27
3)	Transmissions damaged	-	37
4)	Transfers damaged	-	25
5)	Fire control system damaged	-	37
6)	Electrical system damaged	-	49
7)	Armament system damaged	-	44
8)	Track damaged	-	136
Total systems damaged			425

The number of damages for each component were then divided by the total number of vehicles damaged to get a relative percentage of the amount of damage each system had sustained. These percentages when summed are greater than one which reflects the fact that a single tank can have more than one component damaged. This raw data was then normalized over the total number of systems damaged to obtain an

ized over the total number of systems damaged to obtain an empirical probability density function of combat damage by system. A breakdown of the raw data and the resulting empirical probability density function are given in Table 2.

TABLE II
TANK DAMAGES PROBABILITY DENSITY FUNCTION

System or component	Percentage Damaged	Probability Density Function
Totally destroyed	.27237	.16471
Engine	.10506	.06353
Transmission	.14397	.08706
Transfer	.09728	.05883
Fire control system	.14397	.08706
Electrical system	.19066	.11529
Armament system	.17121	.10353
Track	.52918	.31999

The data appear to be relatively uniform across systems except for the amount of damage done to the track components of a tank. This is, however, intuitively as one would expect as the track components of a tank are the most vulnerable and therefore the components most susceptible to damage. This empirical density function for the combat data of tank systems closely approximates actual combat damage as experienced during the Southeast Asia conflict and the Yom Kippur War.

C. ARMORED PERSONNEL CARRIER DAMAGE DATA

The combat damage data extracted from the two databases on armored personnel carriers included all types of the M113 series of vehicles. This included vehicles such as the M577 Command Track, M578 Artillery cargo vehicle and the M901 Improved TOW vehicle. These were included because they all utilize the same chassis and drive train. The only

significant difference among these vehicles is the configuration of the armament and fire control systems. Since this model represents these systems as a whole and not by specific component, it was therefore appropriate to consider all these systems as a single type vehicle. Analysis of the two data bases produced a total of 372 separate incidents which involved the total destruction of the personnel carrier or one or more damages of the components being represented in this model. Of those 372 incidents there was a total of 601 separate components damaged. A breakout of those damages are given in Table 3.

TABLE III
APC DAMAGES BY COMPONENT

1) APCs totally destroyed	-	91
2) Engines damaged	-	84
3) Transmissions damaged	-	77
4) Transfers damaged	-	62
5) Fire control system damaged	-	10
6) Electrical system damaged	-	29
7) Armament system damaged	-	32
8) Track damaged	-	216
Total systems damaged		601

The combat damage data were then treated in the same manner as the tank damage data. The resulting damage percentages and the probability density function is given in Table 4.

Analysis of this probability density function results in approximately the same conclusion as the tank damage data. The damages are relatively consistent across the components with the exception of the track which again is the most vulnerable component.

TABLE IV .
APC DAMAGES PROBABILITY DENSITY FUNCTION

System or component	Percentage Damaged	Probability Density Function
Totally destroyed	.24462	.15141
Engine	.22581	.13977
Transmission	.20699	.12812
Transfer	.16667	.10316
Fire control system	.02688	.01664
Electrical system	.07796	.04825
Armament system	.08602	.05324
Track	.58065	.35940

D. WHEELED VEHICLE DAMAGE DATA

The combat damage data extracted from the two databases on wheeled vehicles included data from all wheeled vehicle types with the exception of low density engineer equipment such as scoop loaders and backhoes. These types of equipment do not fall into the category of main combat power or transportation asset for a unit and for that reason were omitted from the analysis. There were a total of 78 separate wheeled vehicle incidents in these two databases with a total of 104 separate component damages. A breakdown of the component damages is given in Table 5.

These data were then treated the same way as the personnel carriers and tanks with the resulting percentages of damage and probability density function given in Table 6.

Analysis of these results show that the damages sustained by a wheeled vehicle are relatively uniform across all components which suggests that all components of a wheeled vehicle are equally susceptible to damage.

TABLE V
TRUCK DAMAGES BY COMPONENT

1) Trucks totally destroyed	-	14
2) Engines damaged	-	20
3) Transmissions damaged	-	24
4) Transfers damaged	-	21
5) Axle/Suspension damaged	-	25
Total systems damaged		104

TABLE VI
TRUCK DAMAGES PROBABILITY DENSITY FUNCTION

System or component	Percentage Damaged	Probability Density Function
Totally destroyed	.17949	.13462
Engine	.25641	.19231
Transmission	.30769	.23077
Transfer	.26923	.20192
Axle/Suspension	.32051	.24038

E. ARTILLERY DAMAGE DATA

The database for artillery component damages was very small. There was only a total of 11 separate artillery pieces which were either destroyed or damaged. Of these 11 there was a total of 18 components damaged. Although it was a very small sample compared to the other three vehicle systems the data were handled in the same manner. The vehicles included in this category were the M109 and M110 Self Propelled Howitzers. The breakdown of the combat damages are given in Table 7.

TABLE VII
ARTILLERY DAMAGES BY COMPONENT

1) Howitzers totally destroyed	-	1
2) Engines damaged	-	3
3) Transfers damaged	-	1
4) Fire control system damaged	-	1
5) Electrical system damaged	-	3
6) Armament system damaged	-	5
7) Track damaged	-	4
Total systems damaged		18

The resulting damage percentages and probability density function are given in Table 8.

TABLE VIII
ARTILLERY DAMAGES PROBABILITY DENSITY FUNCTION

System or component	Percentage Damaged	Probability Density Function
Totally destroyed	.09091	.05555
Engine	.27273	.16667
Transfer	.09091	.05555
Fire control system	.09091	.05555
Electrical system	.27273	.16667
Armament system	.45455	.27778
Track	.36364	.22222

Because of the small sample size many of the values in the empirical probability density function are repetitive. These values, however, appear to be as expected in that half of the total damages were between the armament system itself and the track.

F. DISCUSSION OF DATA

Although the values in the probability distribution functions are not to be considered as absolutes in determining combat damages in simulation modelling, they are based on historical figures and as such are probably more reliable than numbers obtained from other sources. These values when utilized by the MRM will reasonably represent the damages that would be expected to appear in a real life combat situation and should realistically reproduce combat damages.

IV. MODULE DECISION LOGIC AND DESIGN

A. INTRODUCTION

This chapter describes the decision logic utilized in MRM and provides an explanation of the various queues used throughout the program. It provides a step-by-step description of the maintenance and recovery algorithms and decisions. The general processes involved are identified and described and the structure of the model components and their interrelationships are discussed in detail. The actual decision logic and routines throughout this simulation are identical for all four categories of vehicles that are modeled. This description of the logic and design of the model will refer to only the tank maintenance and recovery routine for brevity but applies universally to all four maintenance and recovery routines. Any differences which are present in the module as a whole will be addressed as necessary.

1. Maintenance and Recovery Queues

For each repair part in the MRM there are a total of six queues. These queues are:

- a) Under repair
- b) Waiting mechanics
- c) Waiting parts
- d) Return time
- e) Evacuation to rear
- f) Repaired and returned

These queues represent the various dispositions that a vehicle can be in at any given time. For the armored personnel carriers, tanks and artillery pieces (which have eight separate repair parts represented) there are a total of forty eight queues each. The wheeled vehicles with four repair parts represented have twenty four queues. This

amounts to a total of 168 queues being utilized by this model for the vehicles. There are also two other queues which handle the evacuation times for the two maintenance support teams (MST) for a total of 170 queues for the MRM.

a. Under Repair Queue

This queue contains all those vehicles for which there were sufficient repair parts on-hand and enough mechanics available to repair them.

b. Waiting Mechanics Queue

This queue contains all those vehicles for which there were parts on-hand but there were not enough mechanics available to perform the required repairs. When this queue is entered the appropriate repair part is decremented from the repair parts stockage so that when mechanics become available it will automatically transfer to the Under Repair queue.

c. Waiting Parts Queue

This queue contains all those vehicles for which there were not sufficient repair parts available. Vehicles in this queue remain there regardless of how many mechanics are available. This will be the first possible queue that a vehicle requiring repair can enter.

d. Return Time Queue

This queue relates the time that vehicles will be completed with their repairs. It is entered at the same time a vehicle enters the Under Repair queue and is then checked continually against the current simulation time to determine if repairs are completed. On completion, the vehicles are transferred to the repaired and returned queue.

e. Repaired and Returned Queue

This queue contains all those vehicles that have been placed under repair and have been completed. These vehicles are considered to be available for return to the owning unit as a completely functional vehicle.

f. Evacuation Time Queue

This queue contains the time of arrival of vehicles evacuated from the forward maintenance support teams to the Direct Support maintenance company. It relates evacuation time to current time and will be integrated with the transportation network module which will determine the time delay inherent in transporting pieces of equipment from the front battle areas to the rear area. Currently the time delay is a user supplied input to the MRM.

g. Evacuation to Rear Queue

This queue is entered at the same time as the evacuation time queue but keeps track of the total vehicles being evacuated from the maintenance support teams to the DS maintenance company.

B. STRUCTURE

The maintenance and recovery module is a discrete event simulation model. It has been initially run using a time step of one hour. The program is designed however, to accommodate any time step a user would care to designate. As an example, if the time step desired is 12 hours the various time parameters in the model such as evacuation time, or repair and return time would be adjusted to reflect the 12 hours in terms of days. (i.e. instead of a 6 hour evacuation delay it would be reflected as a 0.25 day delay.) As such, any time step can be utilized by the model with minimal code modification.

1. Initialization of Model (See Section 1, Appendix A)

The initialization of MRM allows the user to specify various configurations of maintenance support. The model has three distinct maintenance elements represented; designated as a Direct Support maintenance company and two forward deployed maintenance support teams. The strength and composition of these three elements can be changed and varied according to the desires of the user. The user may elect to

conduct all maintenance in the rear Direct Support company by initializing the number of mechanics in the forward maintenance support teams to zero. This would result in all repair jobs located in the forward areas to require evacuation and would therefore incur a time delay. Similarly the user may elect to have a large portion of the total maintenance capability in the forward deployed maintenance support teams. The user then has the ability in MRM to change the number of mechanics in each element and the composition of those elements.

a. Types of Mechanics

The simulation utilizes five different types of mechanics: tank mechanics, wheeled vehicle mechanics, armament mechanics, fire control mechanics, and electrical mechanics. Each type of mechanic has its own set of repair jobs that it can accomplish. As opposed to FORCEM which assumes that each mechanic can perform repairs in all categories, MRM allows for no cross-utilization of mechanics between maintenance categories. This was done because it more accurately depicts the actual capabilities of the mechanics in the field today.

Only two of the five mechanic types represented in MRM can perform more than a single type of repair: the tank mechanic and the wheeled vehicle mechanic. The tank mechanic can perform five different types of repairs: engines, transmissions, transfers, final drives and track. He can repair these five components on tanks, armored personnel carriers, and self propelled howitzers. As such this mechanic, as in a real maintenance unit, is the largest group of mechanics. In MRM the tank mechanic is utilized in three of the four routines. The wheeled vehicles have their own mechanic which can perform all the repairs represented for wheeled vehicles, i.e. engine, transmission, transfer and the axle/suspension system. The other three mechanic types handle one repair each, either the electrical, fire

control or armament systems, but they can repair them for all three tracked vehicle categories.

b. Allowable Workload Initialization

One of the determining factors in the evacuation decisions of this model is the allowable workload of the two forward deployed maintenance teams. The allowable workload is in units of manhours per type of mechanic in the team. This means that there is a different value for each mechanic type in each of the two forward teams. These values can be adjusted by the user to reflect different evacuation policies. Depending on the number of mechanics in each team the allowable workload would indicate how much of a backlog of maintenance repair in manhours is going to be allowed before the damaged vehicles must be evacuated to the rear Direct Support company.

c. Initial On-hand Quantities of Repair Parts

The initialization of the on-hand quantities of repair parts in each of the three maintenance elements can be utilized to represent different maintenance policies. If only those repairs that take less than a certain amount of time to repair are to be completed by the forward teams, then those repair parts would be the only ones stocked. The others would be located at the DS maintenance company.

d. Mechanics Required and Time to Repair

The initialization of these two parameters can be a user-defined parameter. However, specific data can be utilized from the maintenance allocation charts in the technical manuals for particular items of equipment. These charts specifically delineate the approximate manhours required to complete a specific repair. From this data the number of mechanics and the approximate time to repair an item can be determined. An example of a maintenance allocation chart is given in Figure 4.1.

SECTION II. HULL AND RELATED COMPONENTS

(1) GROUP NO.	(2) COMPONENT/ ASSEMBLY	(3) MAINT. FUNC.	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQPT.	(6) REMARKS
			C	O	F	H	D		
0	POWERPACK ASSEMBLY	Inspect Test Service Remove/ Install Replace Repair		0.2 8.6 6.6 5.4 5.4 2.8	 11.8			9 1.2.9.12.27 1.9.12 1.9.12 1.9.12 1.3.9.12. 14.15.18	K
01	ENGINE								
0120	ENGINE ASSEMBLY	Inspect Test Service Adjust Replace Repair Overhaul	0.2	0.1 1.9 0.4 0.5 0.8	0.1 6.8 3.9		 • •	9 1.27 9.12 27 3.9 1.3.9.12.14. 15.27	E
0121	COMPRESSOR ASSEMBLY- FORWARD ENGINE MODULE	Replace Repair Overhaul		0.6	6.0		• •	3.15.26 9.11	
	SCREEN ASSEMBLY	Replace Repair		0.2	1.0			9 13.15.25	
	LINER ASSEMBLY, COMBUSTOR	Inspect Replace Repair		0.1 0.2			•	9.11 9.11	
	IGV AND BLEED ACTUATOR	Replace Repair		0.3 0.2			•	9.11 1.9.11.27	O
	VALVE, BUTTERFLY, AIR-BLEED	Replace Repair		0.3			•	1.9.11	

Figure 4.1 Maintenance Allocation Chart Example.

C. DESIGN AND DECISION LOGIC DESCRIPTION

The actual design and decision processes utilized in MRM are discussed in the following sections. As stated earlier the MRM is a discrete event time step simulation. This presentation will focus primarily on the tank maintenance and recovery routines but represents the decision logic and processes for all four routines.

At each time step data is input into MRM from ALARM reflecting the total number of vehicles by category that have been assessed as having been hit and damaged during the last time step. At this point MRM takes those vehicles and assesses specific repair requirements based on the empirical probability density functions described in Chapter 3. (see also section 2, appendix A) These repair requirements will be determined for the two forward support maintenance elements and the rear DS company.

1. Initial Queue Allocation Routine (See Figure 4.2)

a. Repair Parts Allocation

Based on the initial input of data, the repair requirements will enter a queue allocation routine. The amount of damage by repair part that has been determined from the probability distribution function is compared with the current stockage of repair parts of that type that are on-hand. If sufficient quantities of parts to satisfy the demand are available, that number of repair jobs go into a waiting repair status and the appropriate number of repair parts are decremented from the on-hand quantity. If there are not enough repair parts to satisfy the demand, the number of jobs that can be repaired with the stocks on-hand go into the waiting repair status. The remainder of the repair jobs enter the waiting parts queue as of that time step. The on-hand stockage of that repair part will then reflect a zero balance.

b. Mechanic Allocation

Upon assignment of those jobs that are in the waiting repair category from above, the number of repair jobs by category is multiplied by the number of mechanics that are required to complete the repair. This will result in the total number of mechanics, by type, that will be required to repair all of the jobs in that waiting repair category. If there are a sufficient number of mechanics available to complete the repairs, those repair jobs enter the under repair queue as of that time. Concurrently a return time queue is initiated which keeps track of time so that when the designated time to repair has passed, the repair jobs that were under repair are completed. The number of mechanics by category that are available for repair will be decremented by the total number of mechanics that were utilized. If there were not enough mechanics to complete the repair work, that percentage of work that can be completed by the mechanics on-hand enter the under repair queue and the remainder enter into a waiting mechanics queue as of that time step. The on-hand number of mechanics available is then set to zero.

c. Running Totals

A running total is maintained which indicates the total number of repair jobs that are either under repair, waiting parts or waiting mechanics. There is also a workload computation done at this point which multiplies those jobs that are waiting mechanics by the manhours that would be required to repair each job. This value is used later in determining if any of the waiting mechanics jobs should be evacuated.

2. Workload Computations (See Figure 4.3)

This routine calculates the maintenance workload at each of the two forward support teams and evacuates any repair work which exceeds their capability to return in a

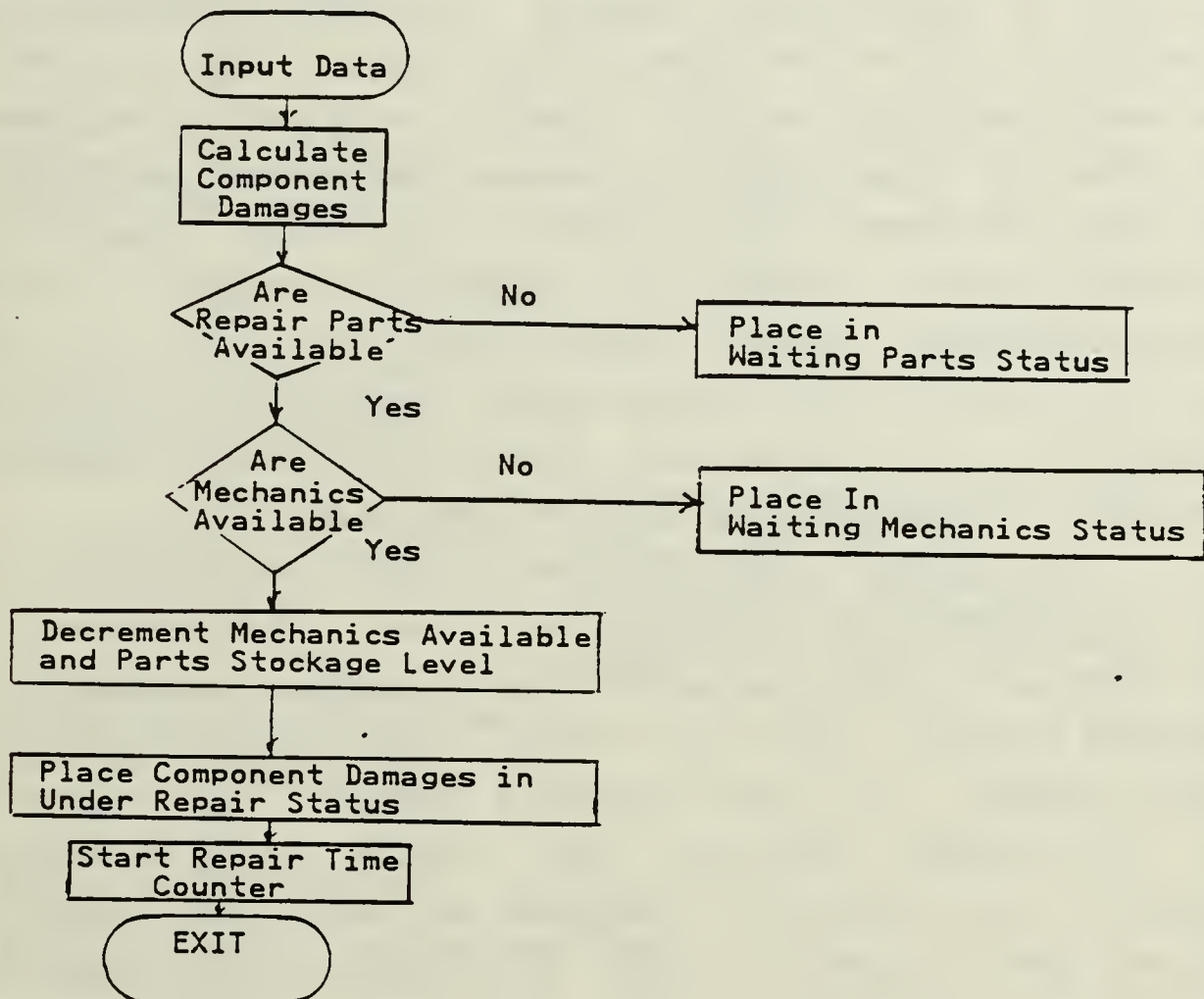


Figure 4.2 Initial Queue Allocation Routine.

designated timeframe. A current workload is calculated for each mechanic type by summing across those repair jobs whose workload indicates that there are repairs waiting mechanics. If the current workload exceeds the allowable workload that was specified in the initialization stage of the model, then those repairs that were waiting mechanics are evacuated to the rear DS maintenance company. The actual evacuation is sequential in that the repairs that require the longest time are evacuated first and the overall workload is recomputed. The order of evacuation for tanks, personnel carriers and howitzers is track, final drives, transfers, transmissions and then engines. Since the armament, electrical and fire control mechanics repair only one component, they will evacuate all repairs that exceed their capability. The order of evacuation for the wheeled vehicles is axle/suspension, transfers, transmissions and then engines.

The actual routine first determines if the current workload exceeds the allowable workload. If it does, then the amount of workload above the allowable is computed and compared against the total track workload of that maintenance element. If the excessive workload is greater than the total track workload, the entire track workload is placed in an evacuation queue as of that time step. The process then repeats for the remaining repair parts until the current workload is less than the allowable workload. If the excessive workload does not exceed the total workload of a particular component then only that portion of the workload above the allowable will be evacuated. Concurrent with the evacuation queue, an evacuation time queue is also established. This time indicates the delay of repair resulting from the in-transit time required for evacuation. Currently this is a user specified input during the initialization phase but will eventually be integrated with the transportation network methodology to determine the time required for evacuation.

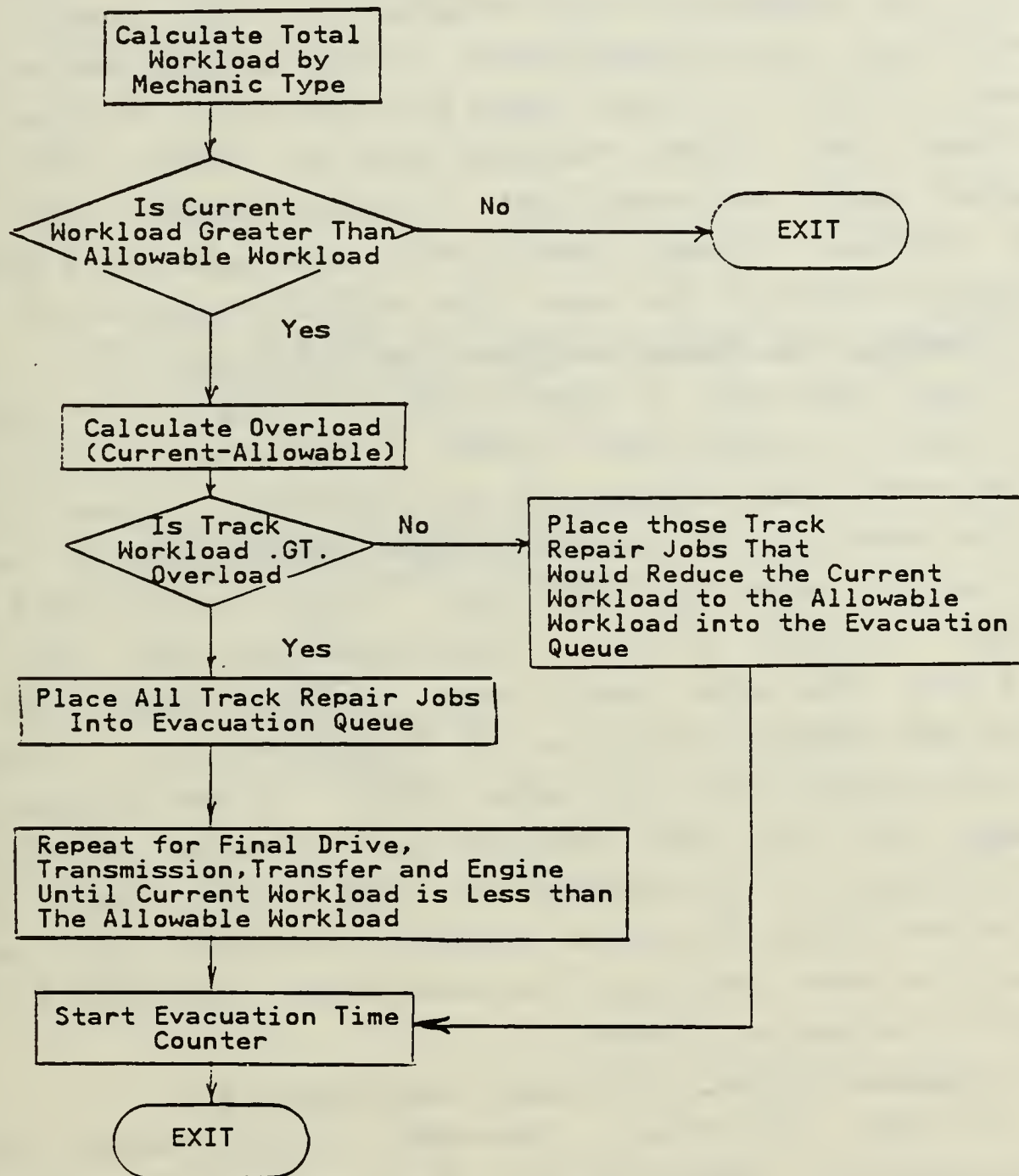


Figure 4.3 Workload Computations.

3. Evacuation Time Routines (See Figure 4.4)

As the model steps through time, jobs that have been evacuated from the forward maintenance support teams will eventually arrive at the DS maintenance company. At each time step the evacuation time routines will loop through all the evacuation times established in the repair evacuation routines. If any of those times are less than or equal to the current time, those evacuated jobs are removed from the evacuation queue and enter into a waiting repair queue at the DS company. These repair jobs then enter the queue allocation routine at the next time step for disposition.

4. Repair and Return Routine (See Figure 4.5)

Each time that a repair job is placed in the under repair queue, a return time queue is initiated to indicate the time when those repairs will be completed. At each time step, the model cycles through these return times to check if any repairs have been completed. If the return time is less than or equal to the current time the jobs will be removed from the under repair queue and will enter into a repaired and returned status as of that time step. At that point the running total for under repair is decremented by the number that have been completed and the number of available mechanics is incremented by that number times the number of mechanics that were required for that repair job. Once this has been completed the model then investigates all the waiting mechanics queues.

5. Waiting Mechanic Routines (See Figure 4.6)

At each time step, the model cycles through the waiting mechanics queues when it has completed the repair and return routines. It cycles through all the queues starting with the oldest waiting mechanics repair jobs and begins assigning the newly returned mechanics from the previous routine. At each time step it determines if there are repairs waiting mechanics, and if so, it determines

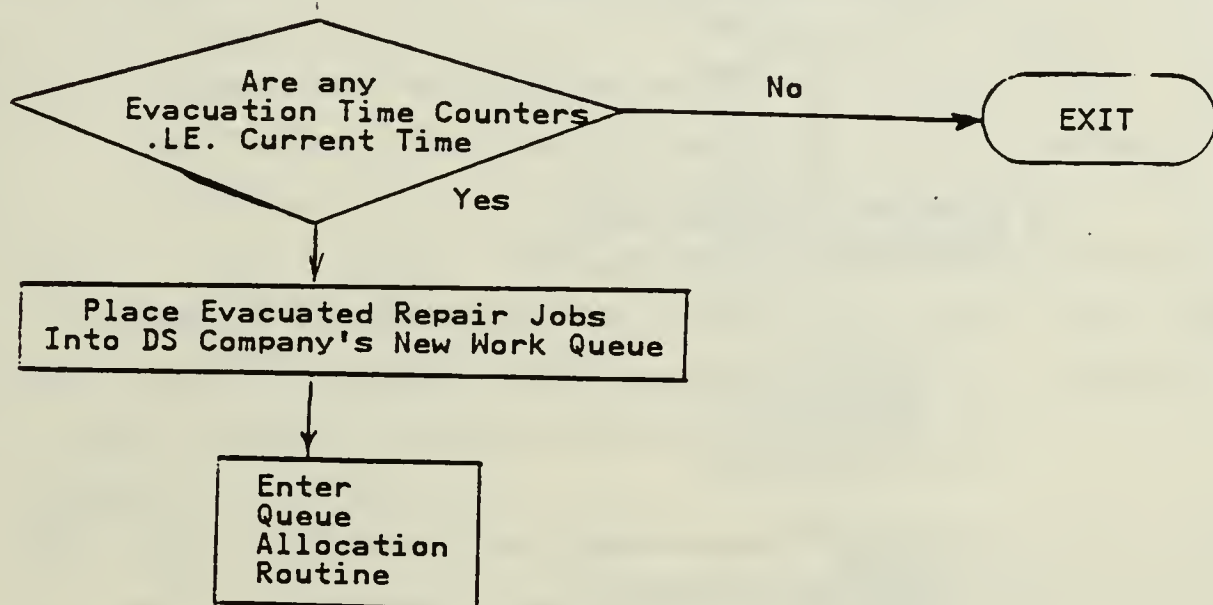


Figure 4.4 Evacuation Time Routine.

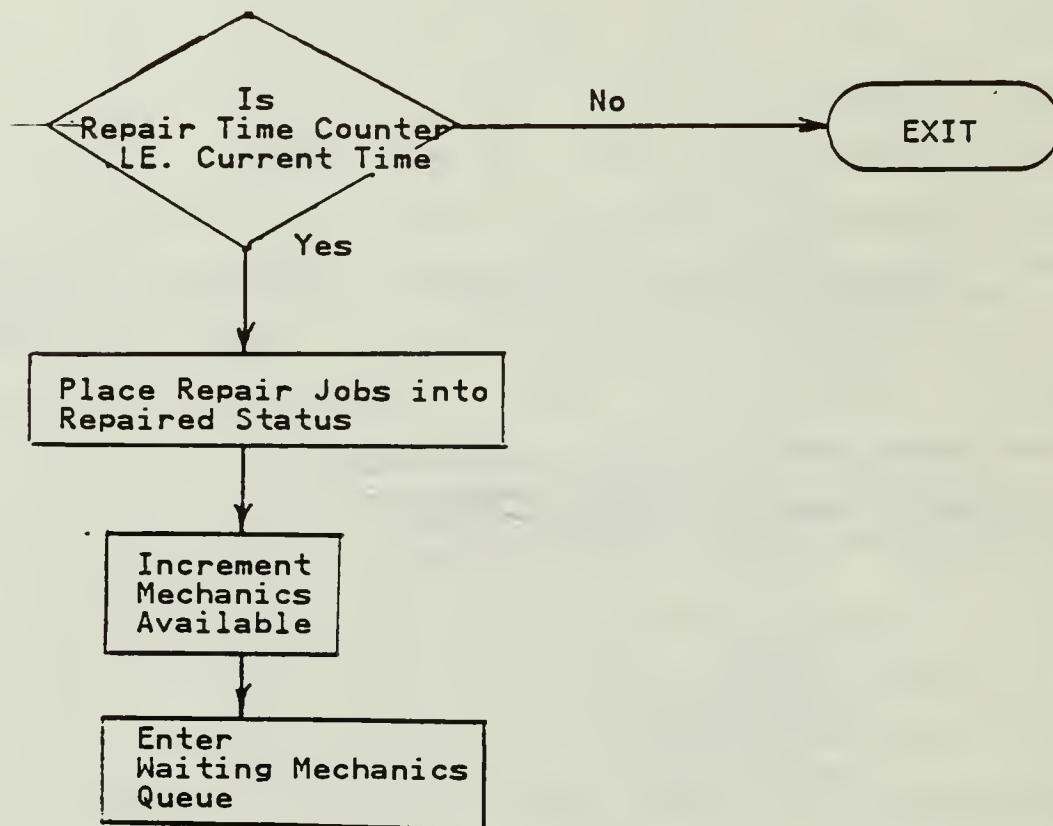


Figure 4.5 Repair Completion Routine.

whether there are mechanics available to do the repairs. If the answer to both is yes, the model then determines the total number of mechanics required to complete the repairs and divides it by the total number of mechanics that are available. If the ratio is less than or equal to one then there are enough mechanics to complete all the repairs in that category that are waiting mechanics. Those repair jobs that were in the waiting mechanics queue are removed and placed in the under repair queue. The total number of mechanics, and the total number of repair jobs waiting mechanics are then decremented. If the ratio is greater than one, then there are not enough mechanics to complete all the repairs, so the number that can be repaired by the mechanics available is removed from the waiting parts queue and placed in the under repair queue. The waiting mechanics queue at that time step is decremented by that same amount and the model then investigates the next mechanic type for available mechanics and repairs waiting mechanics.

6. Output

The final part of the model is the generation of the output. At each time step the output monitors the various queues in the model and presents them in tabular form. From this output repairs can be traced throughout the system. A detailed explanation and analysis of this output is presented in Chapter 5.

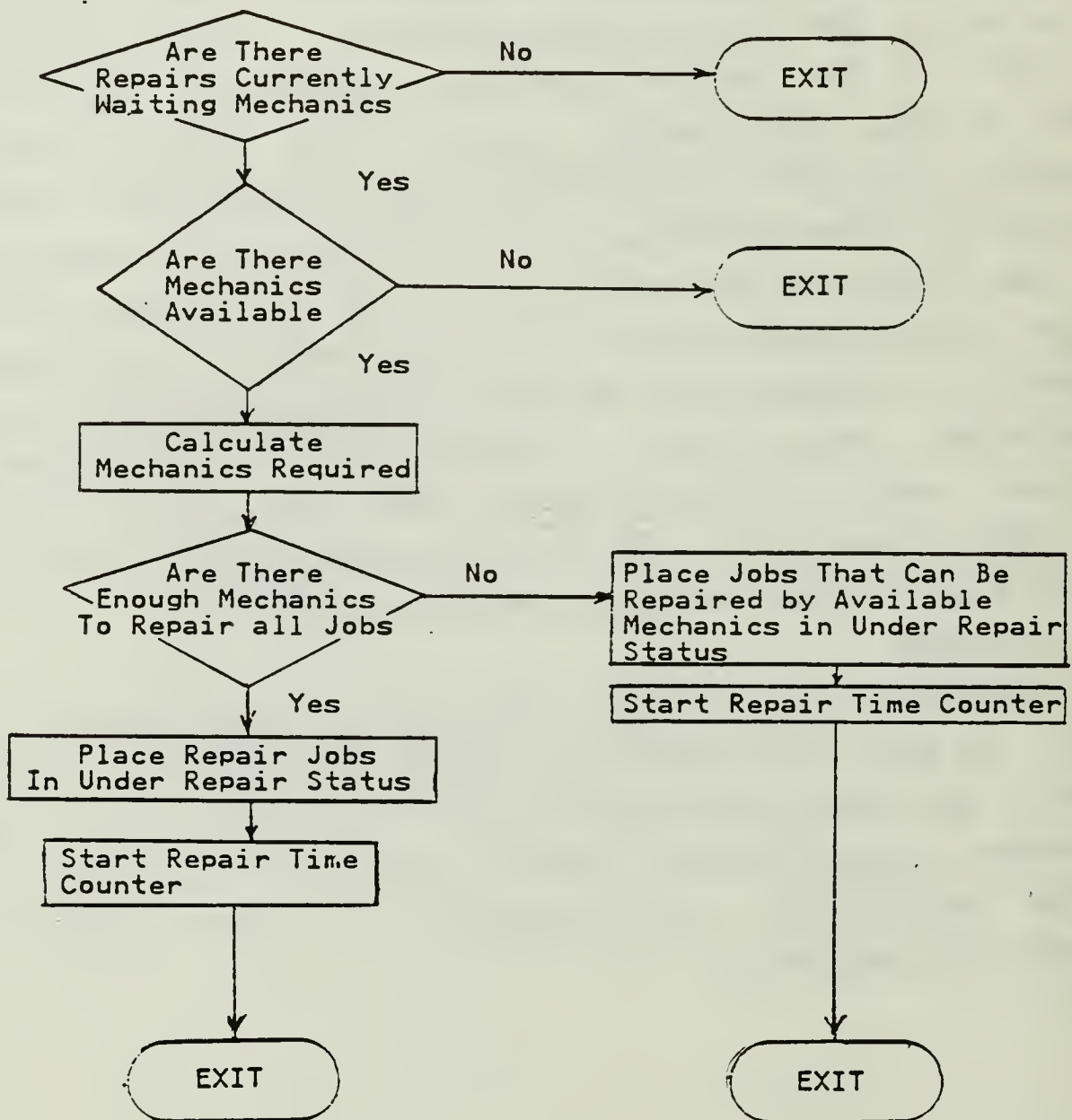


Figure 4.6 Waiting Mechanics Allocation Routine.

V. ANALYSIS OF OUTPUT

A. DISCUSSION OF INITIAL PARAMETERS

This simulation was developed to assist a decision maker in evaluating alternatives with respect to battlefield maintenance and recovery. Specifically this model gives the decision maker the capability to evaluate how battlefield maintenance can affect the combat power of a unit. The model allows a user to reallocate resources among three separate maintenance entities to observe how overall maintenance capability is affected and how this in turn can affect the overall operational readiness of a unit.

Two scenarios are evaluated using the simulation. The first employs the concept of all maintenance being conducted at the DS maintenance company with no fix forward capability. The second run utilizes the same total numbers of mechanics and repair parts but has two forward support maintenance teams fixing forward. The objective of the analysis is to determine the difference in total number of vehicles repaired and returned over time for these two maintenance concepts. A selected sample of the output generated from these runs is given in Figures 5.1 to 5.12.

B. RECOVER AND REPAIR CONCEPT OF MAINTENANCE

The output for this concept of maintenance is contained in Figures 5.1 to 5.5. Figure 5.1 shows the initial time period of the model. The initial damages were assessed and as can be seen there are no repair jobs under repair at the two forward support maintenance teams. Figure 5.2 shows those damages incurred by the two forward battalions in an evacuated status, and the eventual receipt of the evacuated jobs from the 1st Bn MST by the DS company at time period seven. The evacuation time set for these runs were six hours

from the 1st battalion and four hours from the second battalion. In order to check the accuracy of the algorithms and routines in the model itself, Figures 5.3 to 5.6 were included. From these one can track the change in status over a single time step. Tracking tank engines from time periods 6 to 7 shows that at time period 6 there were 0.95 tanks under repair for engines. In Figure 5.4 we see that the DS company has received no repair jobs for engines from the 1st battalion and 0.70 repair jobs from the 2nd battalion. From the models empirical probability density function we know that tank engines will be damaged with a probability of 0.06353. At time step seven the data input to the model for total tank damages for the DS maintenance company was 17 vehicles. Therefore new engine damages for the DS company at time period seven should equal $(17 \times 0.06353) + .00 + 0.70 = 1.78$. This is represented under the new damages column in Figure 5.5 for time period seven. This shows that the evacuation routines work correctly and that evacuated equipment from the two forward battalions are being added to the maintenance queues of the DS company.

The under repair columns from these two time periods show that at time six there were 0.95 engines under repair. At time period seven there were a total of 0.06 repairs completed on tank engines. This would then equate to a total of 0.89 engine repair jobs from earlier time periods still under repair. If the 1.78 new damages as listed under the new damages column are added, the new under repair total is 2.67. This is what is indicated at time period seven. (see Figure 5.4)

Figure 5.6 shows the results after the 15th time step, which was the final time step in this simulation and Figure 5.13 shows the final totals of repair jobs completed. This figure will be discussed in more detail after the fix forward concept is presented.

C. FIX FORWARD CONCEPT OF MAINTENANCE

The second run of MRM investigated the fix forward concept of maintenance. The same number of mechanics and repair parts were utilized, however, two maintenance support teams were sent forward with the forward combat battalions. Figures 5.6 to 5.9 show the same time steps as shown for the recover and repair simulation.

Figure 5.6 shows the initial time step of the simulation. As can be seen, all three maintenance elements have repair jobs in the under repair status. Figure 5.7 shows the three elements at time period six. Both forward maintenance units have repair jobs waiting mechanics, but as can be seen from Figure 5.7, the only type of repair job that has exceeded the allowable workload level is the electrical system repairs. The same analysis of time period seven as was done for the recover and repair simulation shows that all the algorithms and routines are functioning correctly. The input stream for this run was identical to the recover and repair simulation. A Check of the new damages to the tank engines in the DS company shows that the only difference between the two runs was the repair jobs that were evacuated from the forward maintenance teams in the recover and repair simulation. Figure 5.10 shows the results of time period seven and Figure 5.11 shows the final time step in the fix forward simulation.

D. OVERALL RESULTS OF THE TWO SIMULATIONS

The major objective of the analysis was to determine if there is any difference in the relative maintenance effectiveness of these two different concepts of maintenance support. Figure 5.12 shows the total repairs completed by each concept as of the final time step. Summing the total repair jobs across all the components gives a total of 73.42 tanks under the recover and repair concept and 105.11 tanks under the fix forward concept.

Analysis of the data was done to investigate these results. Figures 5.12 to 5.13 show the total results from these two runs in the categories of total repairs completed, mechanics remaining at each time step, and the number of tanks waiting mechanics at each time step. Figures 5.14 to 5.17 show a breakout of the mechanic categories by mechanic type. Each of these Figures show a significant change at time period seven. Analysis of the data input for this time period indicated that there was a large influx of damaged equipment at that point.

Figure 5.10 shows the repair totals in each of the two runs over the fifteen time steps. The first repairs are completed at time period three. From time periods three through eight, the slope of the total repair curve is greater for the fix forward concept than for the recover and repair concept. This indicates a repair lag resulting from the evacuation time lag. At time period eight this initial lag has been overcome and the slope of the total repair curves for both concepts are approximately equal. This result was surprising. The a priori postulate was that as the evacuation lag was overcome the repair total for the recover and repair concept would be greater than the fix forward concept because of increased economies of scale. With the consolidation of all the mechanics in one element it was felt that total repair rate would increase. The model results indicated that this is not necessarily the case. Although the evacuation lag was overcome, the difference in total repairs for each concept remained essentially constant. With the total number of mechanics being equal in both runs the number of tanks which can be put in an under repair status has an upper limit. This limit is attained when all available mechanics are repairing vehicles. Regardless of where the mechanics are located they cannot repair and return vehicles at any faster rate. If this

saturation is realized then there will be little difference in the repair rates of the two concepts.

Figures 5.18' and 5.19 give the total number of tanks under repair and in an evacuated status. The evacuated totals for the recover and repair concept are much larger than for the fix forward concept as expected. The difference between these curves is the total number of tanks that are unavailable for repair because they are in transit between the forward and rear elements. In contrasting the waiting mechanics graph (Figure 5.13) and the evacuation graph (Figure 5.19) we can see the tradeoff between the two maintenance concepts. As an example, at time period 7 the number of tanks waiting mechanics is approximately 48 for the fix forward concept. For the recover and repair concept the number of tanks evacuated at this same time step is approximately 55 more than the fix forward concept. This indicates that these tanks are going to be placed in one of two queues; either evacuated or waiting mechanics. In the recover and repair concept evacuation time is uncontrolled. It depends on the relative position of the maintenance elements and the combat elements on the battlefield. In the fix forward concept the number of mechanics in each forward element can be changed which could result in a lessening of the waiting mechanics queues in them. As a result MRM can assist us in deciding on an optimal mix of assets between the forward elements and the rear DS company.

Figures 5.11 through 5.17 show the total mechanics remaining at each time step, the total tanks waiting mechanics at each time step and a breakout of each of these categories by mechanic type.

Figure 5.12 shows the mechanics remaining at each time step. From this Figure we can see that, initially, the recover and repair concept has a lot of mechanics not being utilized. It is not until the evacuation lag has been

overcome that the difference between mechanics remaining under the two concepts decreases. When this Figure and the total repair Figure are compared, it indicates that the fix forward concept of repair tends to provide a more efficient initial utilization of mechanics.

Figure 5.13 shows the number of tanks that are waiting mechanics at each time step. This Figure indicates that the relative number of vehicles waiting mechanics is greater for the fix forward concept. This is a result caused by the relative size of the fix forward teams. It can be seen from the Figure that the recover and repair concept has an increase in jobs waiting mechanics beginning at time period 11 which results from the evacuation lag. At time period seven, when there was a significant increase in damaged vehicles, there were many vehicles placed in a waiting mechanics status in the forward elements. Those repairs jobs in the recover and repair concept were all evacuated and arrived at the rear DS company between time periods eleven and thirteen. Due to the greater number of mechanics consolidated in one element in the recover and repair concept, the relative magnitude of the waiting mechanics queue was smaller.

Figures 5.14 to 5.17 show a breakout by mechanic type for the two categories discussed above. These were included to show that although the graphs show mechanics remaining, those mechanics cannot repair all damages. Specific shortages which drove the total waiting mechanics Figure were in all categories in the fix forward concept and in the electrical mechanic in the recover and repair concept. This would indicate that either an increase in the numbers of these mechanics is required or a different mix of fix forward assets and rear area assets is needed.

E. SUMMARY

Chapters 4 and 5 have focused on the tank routine as an example. There are however four separate, interrelated routines that also deal with the armored personnel carriers, artillery pieces and wheeled vehicles. The tank routines were the only ones shown in this thesis for brevity. The other routines are identical except for the empirical probability density functions discussed in chapter three.

Overall MRM has provided information and data relative to the two maintenance concepts being investigated. It provides the user with the ability to assess the final results of a maintenance concept in order to help him decide which concept to use. Upon final integration with the Airland Research Model this maintenance module will provide a realistic simulation of the repair and return of damaged combat vehicles in any scenario.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 1.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.64	0.00	0.00	0.00	0.00	99.36
XMN	0.87	0.00	0.00	0.00	0.00	59.13
XFR	0.59	0.00	0.00	0.00	0.00	29.41
TRK	3.20	0.00	0.00	0.00	0.00	56.80
FCN	0.87	0.00	0.00	0.00	0.00	29.13
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.04	0.00	0.00	0.00	0.00	28.96
ELE	1.15	0.00	0.00	0.00	0.00	18.85

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 1.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.51	0.00	0.00	0.00	0.00	99.49
XMN	0.70	0.00	0.00	0.00	0.00	59.30
XFR	0.47	0.00	0.00	0.00	0.00	29.53
TRK	2.56	0.00	0.00	0.00	0.00	57.44
FCN	0.70	0.00	0.00	0.00	0.00	29.30
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.83	0.00	0.00	0.00	0.00	29.17
ELE	0.92	0.00	0.00	0.00	0.00	19.08

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 1.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.95	0.95	0.00	0.00	0.00	99.05
XMN	1.31	1.31	0.00	0.00	0.00	58.69
XFR	0.87	0.87	0.00	0.00	0.00	29.13
TRK	4.80	4.80	0.00	0.00	0.00	75.20
FCN	1.31	1.31	0.00	0.00	0.00	28.69
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.55	1.55	0.00	0.00	0.00	28.45
ELE	1.73	1.73	0.00	0.00	0.00	18.27

Figure 5.1 Recover and Repair Time Step 1.

TIME= 1.00 HRS

	EVACUATED FROM 1ST BN (EN ROUTE)	EVACUATED FROM 2ND BN (EN ROUTE)	RECEIVED BY DS FROM 1ST BN AT THIS TIME	RECEIVED BY DS FROM 2ND BN AT THIS TIME
ENG	0.64	0.51	0.00	0.00
XMN	0.87	0.70	0.00	0.00
XFR	0.59	0.47	0.00	0.00
FDR	0.00	0.00	0.00	0.00
TRK	3.20	2.56	0.00	0.00
FCN	0.87	0.70	0.00	0.00
ARM	1.04	0.83	0.00	0.00
ELE	1.15	0.92	0.00	0.00

TIME= 7.00 HRS

	EVACUATED FROM 1ST BN (EN ROUTE)	EVACUATED FROM 2ND BN (EN ROUTE)	RECEIVED BY DS FROM 1ST BN AT THIS TIME	RECEIVED BY DS FROM 2ND BN AT THIS TIME
ENG	3.56	2.35	0.64	0.13
XMN	4.88	3.22	0.87	0.17
XFR	3.29	2.18	0.59	0.12
FDR	0.00	0.00	0.00	0.00
TRK	17.92	11.84	3.20	0.64
FCN	4.88	3.22	0.87	0.17
ARM	5.80	3.83	1.04	0.21
ELE	6.46	4.27	1.15	0.23

Figure 5.2 Recover and Repair Evacuation Example.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 6.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.57	0.00	0.00	0.00	0.00	98.09
XMN	0.78	0.00	0.00	0.00	0.00	57.39
XFR	0.53	0.00	0.00	0.00	0.00	28.24
TRK	2.88	0.00	0.00	0.00	0.00	50.40
FCN	0.78	0.00	0.00	0.00	0.00	27.39
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.93	0.00	0.00	0.00	0.00	26.89
ELE	1.04	0.00	0.00	0.00	0.00	16.54

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 6.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.44	0.00	0.00	0.00	0.00	97.97
XMN	0.61	0.00	0.00	0.00	0.00	57.21
XFR	0.41	0.00	0.00	0.00	0.00	28.12
TRK	2.24	0.00	0.00	0.00	0.00	49.76
FCN	0.61	0.00	0.00	0.00	0.00	27.21
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.72	0.00	0.00	0.00	0.00	26.69
ELE	0.81	0.00	0.00	0.00	0.00	16.31

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 6.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.76	0.95	0.00	0.00	0.19	97.33
XMN	1.04	1.31	0.00	0.00	0.26	56.34
XFR	0.70	0.88	0.00	0.00	0.17	27.55
TRK	3.84	13.44	0.00	0.00	0.00	66.56
FCN	1.04	1.31	0.00	0.00	0.26	26.34
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.24	2.80	0.00	0.00	1.55	25.65
ELE	1.38	4.84	0.00	0.00	0.00	15.16

Figure 5.3 Recover and Repair Time Step 6.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 7.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	2.29	0.00	0.00	0.00	0.00	95.81
XMN	3.13	0.00	0.00	0.00	0.00	54.25
XFR	2.12	0.00	0.00	0.00	0.00	26.12
TRK	11.52	0.00	0.00	0.00	0.00	38.88
FCN	3.13	0.00	0.00	0.00	0.00	24.25
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	3.73	0.00	0.00	0.00	0.00	23.17
ELE	4.15	0.00	0.00	0.00	0.00	12.39

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 7.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	1.65	0.00	0.00	0.00	0.00	96.32
XMN	2.26	0.00	0.00	0.00	0.00	54.95
XFR	1.53	0.00	0.00	0.00	0.00	26.59
TRK	8.32	0.00	0.00	0.00	0.00	41.44
FCN	2.26	0.00	0.00	0.00	0.00	24.95
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	2.69	0.00	0.00	0.00	0.00	24.00
ELE	3.00	0.00	0.00	0.00	0.00	13.31

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 7.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	1.78	2.67	0.00	0.00	0.06	95.55
XMN	2.44	3.66	0.00	0.00	0.09	53.91
XFR	1.64	2.46	0.00	0.00	0.06	25.91
TRK	8.96	22.40	0.00	0.00	0.00	57.60
FCN	2.44	3.66	0.00	0.00	0.09	23.91
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	2.90	4.76	0.00	0.00	0.93	22.75
ELE	3.23	8.07	0.00	0.00	0.00	11.93

Figure 5.4 Recover and Repair Time Step 7.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 15.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.70	0.00	0.00	0.00	0.00	93.46
XMN	0.96	0.00	0.00	0.00	0.00	51.03
XFR	0.65	0.00	0.00	0.00	0.00	23.94
TRK	3.52	0.00	0.00	0.00	0.00	27.04
FCN	0.96	0.00	0.00	0.00	0.00	21.03
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.14	0.00	0.00	0.00	0.00	19.34
ELE	1.27	0.00	0.00	0.00	0.00	8.13

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 15.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.70	0.00	0.00	0.00	0.00	94.16
XMN	0.96	0.00	0.00	0.00	0.00	51.99
XFR	0.65	0.00	0.00	0.00	0.00	24.59
TRK	3.52	0.00	0.00	0.00	0.00	30.56
FCN	0.96	0.00	0.00	0.00	0.00	21.99
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.14	0.00	0.00	0.00	0.00	20.48
ELE	1.27	0.00	0.00	0.00	0.00	9.39

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 15.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	1.65	4.07	0.00	1.65	2.03	84.56
XMN	2.26	5.57	0.00	2.26	2.79	38.84
XFR	1.52	3.76	0.00	1.52	1.88	15.75
TRK	8.32	58.24	0.00	10.87	0.96	2.24
FCN	2.26	7.84	0.00	0.00	2.79	8.84
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	2.69	13.77	0.00	0.00	0.31	4.84
ELE	3.00	10.00	8.02	1.93	3.23	0.00

Figure 5.5 Recover and Repair Final Time Step (15).

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 1.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.64	0.64	0.00	0.00	0.00	99.36
XMN	0.87	0.87	0.00	0.00	0.00	59.13
XFR	0.59	0.59	0.00	0.00	0.00	29.41
TRK	3.20	3.20	0.00	0.00	0.00	56.80
FCN	0.87	0.87	0.00	0.00	0.00	29.13
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.04	1.04	0.00	0.00	0.00	28.96
ELE	1.15	1.15	0.00	0.00	0.00	18.85

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 1.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.51	0.51	0.00	0.00	0.00	99.49
XMN	0.70	0.70	0.00	0.00	0.00	59.30
XFR	0.47	0.47	0.00	0.00	0.00	29.53
TRK	2.56	2.56	0.00	0.00	0.00	57.44
FCN	0.70	0.70	0.00	0.00	0.00	29.30
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.83	0.83	0.00	0.00	0.00	29.17
ELE	0.92	0.92	0.00	0.00	0.00	19.08

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 1.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.95	0.95	0.00	0.00	0.00	99.05
XMN	1.31	1.31	0.00	0.00	0.00	58.69
XFR	0.87	0.87	0.00	0.00	0.00	29.13
TRK	4.80	4.80	0.00	0.00	0.00	75.20
FCN	1.31	1.31	0.00	0.00	0.00	28.69
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.55	1.55	0.00	0.00	0.00	28.45
ELE	1.73	1.73	0.00	0.00	0.00	18.27

Figure 5.6 Fix Forward Time Step 1.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 6.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.57	0.89	0.00	0.00	0.06	98.09
XMN	0.78	1.22	0.00	0.00	0.09	57.39
XFR	0.53	0.82	0.00	0.00	0.06	28.24
TRK	2.88	9.60	0.00	0.00	0.00	50.40
FCN	0.78	1.22	0.00	0.00	0.09	27.39
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.93	2.07	0.00	0.00	1.04	26.89
ELE	1.04	2.50	0.00	0.96	0.00	16.54

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 6.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.44	0.70	0.00	0.00	0.13	97.97
XMN	0.61	0.96	0.00	0.00	0.17	57.21
XFR	0.41	0.65	0.00	0.00	0.12	28.12
TRK	2.24	10.24	0.00	0.00	0.00	49.76
FCN	0.61	1.29	0.00	0.00	0.00	27.21
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.72	2.48	0.00	0.00	0.83	26.69
ELE	0.81	2.50	0.00	1.19	0.00	16.31

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 6.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.25	0.44	0.00	0.00	0.19	97.84
XMN	0.35	0.61	0.00	0.00	0.26	57.04
XFR	0.23	0.41	0.00	0.00	0.17	28.02
TRK	1.28	10.88	0.00	0.00	0.00	69.12
FCN	0.35	0.61	0.00	0.00	0.26	27.04
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	0.41	1.97	0.00	0.00	1.55	26.48
ELE	0.46	3.92	0.00	0.00	0.00	16.08

Figure 5.7 Fix Forward Time Step 6.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 7.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	2.29	2.08	0.00	0.97	0.13	95.81
XMN	3.13	1.04	0.00	3.13	0.17	54.25
XFR	2.12	0.71	0.00	2.12	0.12	26.12
TRK	11.52	9.60	0.00	3.62	0.00	38.88
FCN	3.13	1.50	0.00	2.40	0.17	24.25
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	3.73	2.50	0.00	2.22	0.52	23.17
ELE	4.15	2.50	0.00	1.25	0.00	12.39

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 7.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	1.65	2.16	0.00	0.00	0.19	96.32
XMN	2.26	0.85	0.00	2.11	0.26	54.95
XFR	1.53	0.47	0.00	1.53	0.18	26.59
TRK	8.32	10.24	0.00	4.18	0.00	41.44
FCN	2.26	1.50	0.00	1.46	0.59	24.95
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	2.69	2.50	0.00	1.54	1.14	24.00
ELE	3.00	2.50	0.00	1.25	0.00	13.31

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 7.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	1.08	1.46	0.00	0.00	0.06	96.76
XMN	1.48	2.00	0.00	0.00	0.09	55.56
XFR	0.99	1.34	0.00	0.00	0.06	27.03
TRK	5.44	16.32	0.00	0.00	0.00	63.68
FCN	1.48	2.00	0.00	0.00	0.09	25.56
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.76	2.80	0.00	0.00	0.93	24.72
ELE	1.96	5.00	0.00	0.88	0.00	14.12

Figure 5.8 Fix Forward Time Step 7.

1ST BN MAINT SPT TEAM TANK STATUS REPORT AS OF 15.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.70	0.00	0.00	2.35	0.00	93.46
XMN	0.96	0.00	0.00	3.22	0.95	51.03
XFR	0.65	1.44	0.00	2.18	0.68	23.94
TRK	3.52	13.56	0.00	0.44	0.32	27.04
FCN	0.96	1.50	0.00	0.79	0.78	21.03
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.14	2.50	0.00	1.79	0.31	19.34
ELE	1.27	2.50	0.00	1.25	0.00	8.13

2ND BN MAINT SPT TEAM TANK STATUS REPORT AS OF 15.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.70	0.57	0.00	1.59	0.00	94.16
XMN	0.96	0.78	0.00	2.18	0.07	51.99
XFR	0.65	0.53	0.00	1.47	1.53	24.59
TRK	3.52	11.94	0.00	3.42	0.64	30.56
FCN	0.96	1.50	0.00	0.72	0.61	21.99
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	1.14	2.50	0.00	1.79	0.02	20.48
ELE	1.27	2.50	0.00	1.25	0.00	9.39

DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF 15.00 HRS						
SYSTEM	NEW DAMAGES	UNDER REPAIR	WAITING PARTS	WAITING MECHANICS	REPAIRS COMPLETED	PARTS ON HAND
ENG	0.70	1.21	0.00	0.00	0.19	94.09
XMN	0.96	1.65	0.00	0.00	0.26	51.90
XFR	0.64	1.11	0.00	0.00	0.17	24.58
TRK	8.64	42.08	0.00	0.00	0.96	29.28
FCN	1.74	2.72	0.00	0.00	0.26	20.84
FDR	0.00	0.00	0.00	0.00	0.00	50.00
ARM	2.47	4.41	0.00	0.00	0.10	18.44
ELE	2.65	5.00	0.00	9.94	1.08	0.06

Figure 5.9 Fix Forward Final Time Step (15).

TIME= 15.00 HRS

TOTAL REPAIRS COMPLETED AS OF THIS TIME BY EACH
MAINTENANCE ELEMENT

SYSTEM	1ST BN MST	2ND BN MST	DS MAINT CO
ENG	0.00	0.00	9.72
XMN	0.00	0.00	13.32
XFR	0.00	0.00	8.96
FDR	0.00	0.00	0.00
TRK	0.00	0.00	8.64
FCN	0.00	0.00	13.32
ARM	0.00	0.00	11.39
ELE	0.00	0.00	8.07

TIME= 15.00 HRS

TOTAL REPAIRS COMPLETED AS OF THIS TIME BY EACH
MAINTENANCE ELEMENT

SYSTEM	1ST BN MST	2ND BN MST	DS MAINT CO
ENG	4.19	3.68	4.70
XMN	5.75	5.05	6.44
XFR	2.44	3.41	4.32
FDR	0.00	0.00	0.00
TRK	5.12	6.72	8.64
FCN	5.61	5.79	6.44
ARM	4.67	5.00	7.14
ELE	2.50	2.50	5.00

Figure 5.10 Final Totals of Both Concepts.

TOTAL REPAIRS AT EACH TIME STEP

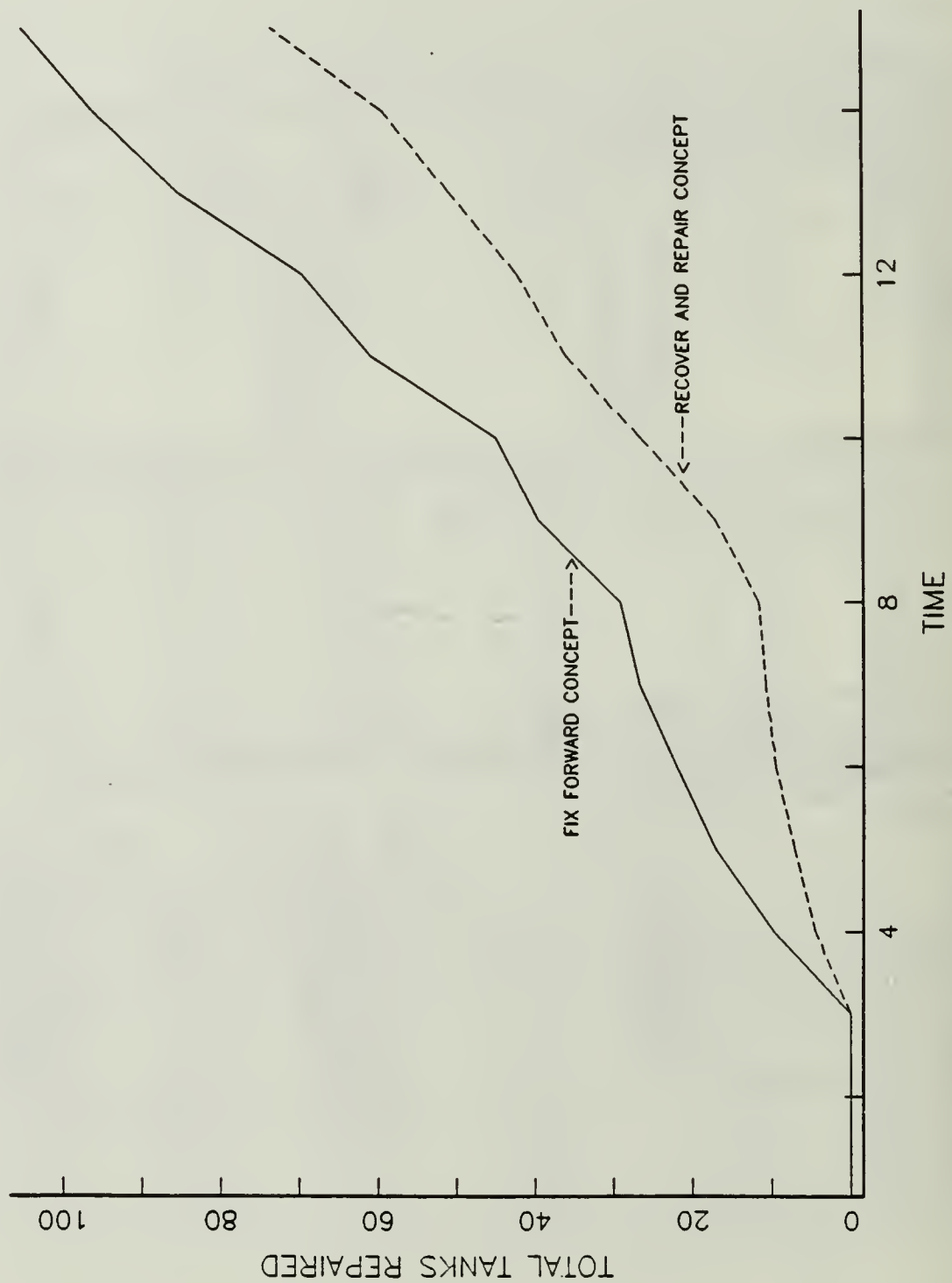


Figure 5.11 Total Repairs.

MECHANICS REMAINING AT EACH TIME STEP

I

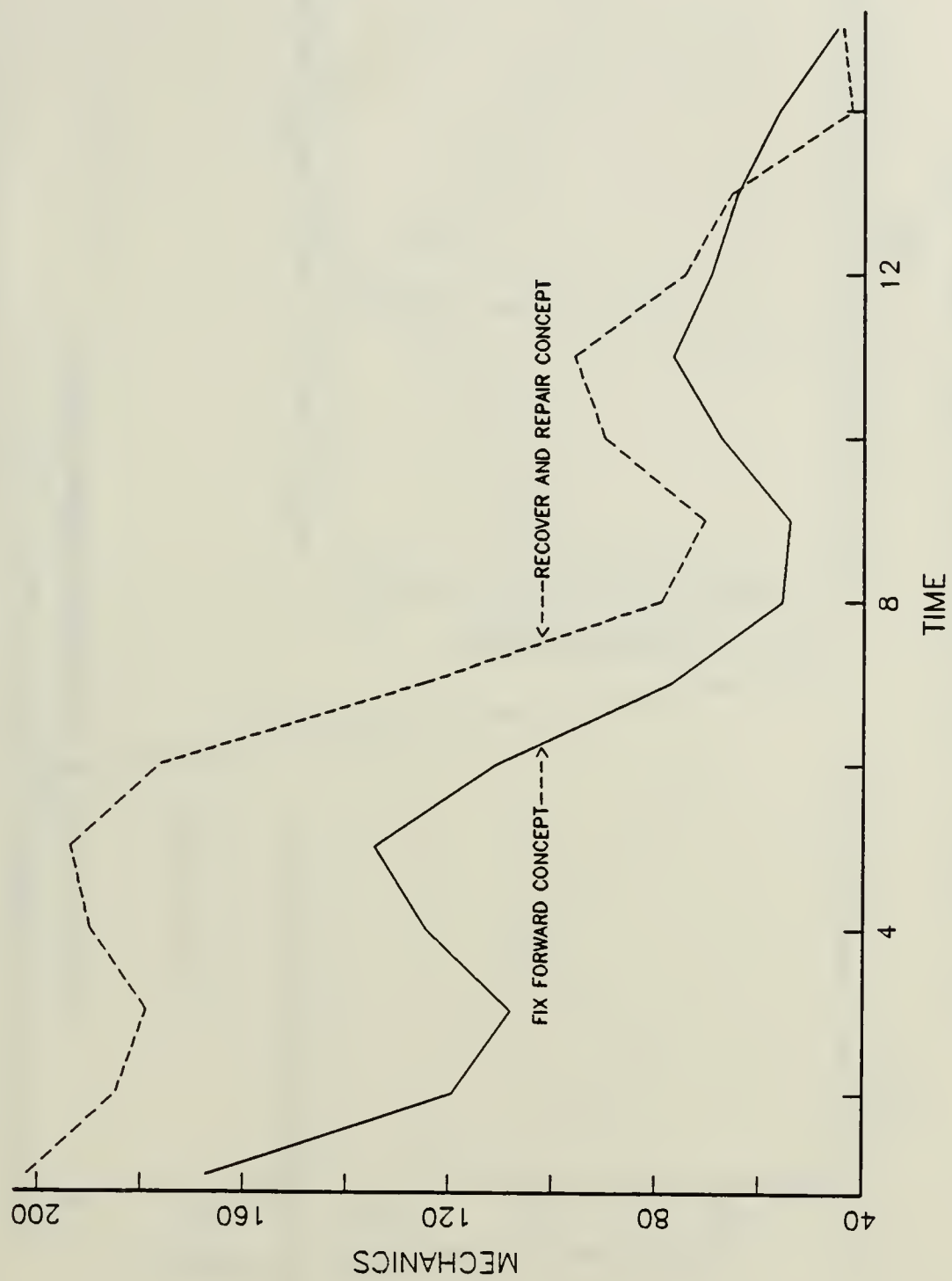


Figure 5.12 Total Mechanics Remaining.

JOBS WAITING MECHANICS AT EACH TIME STEP

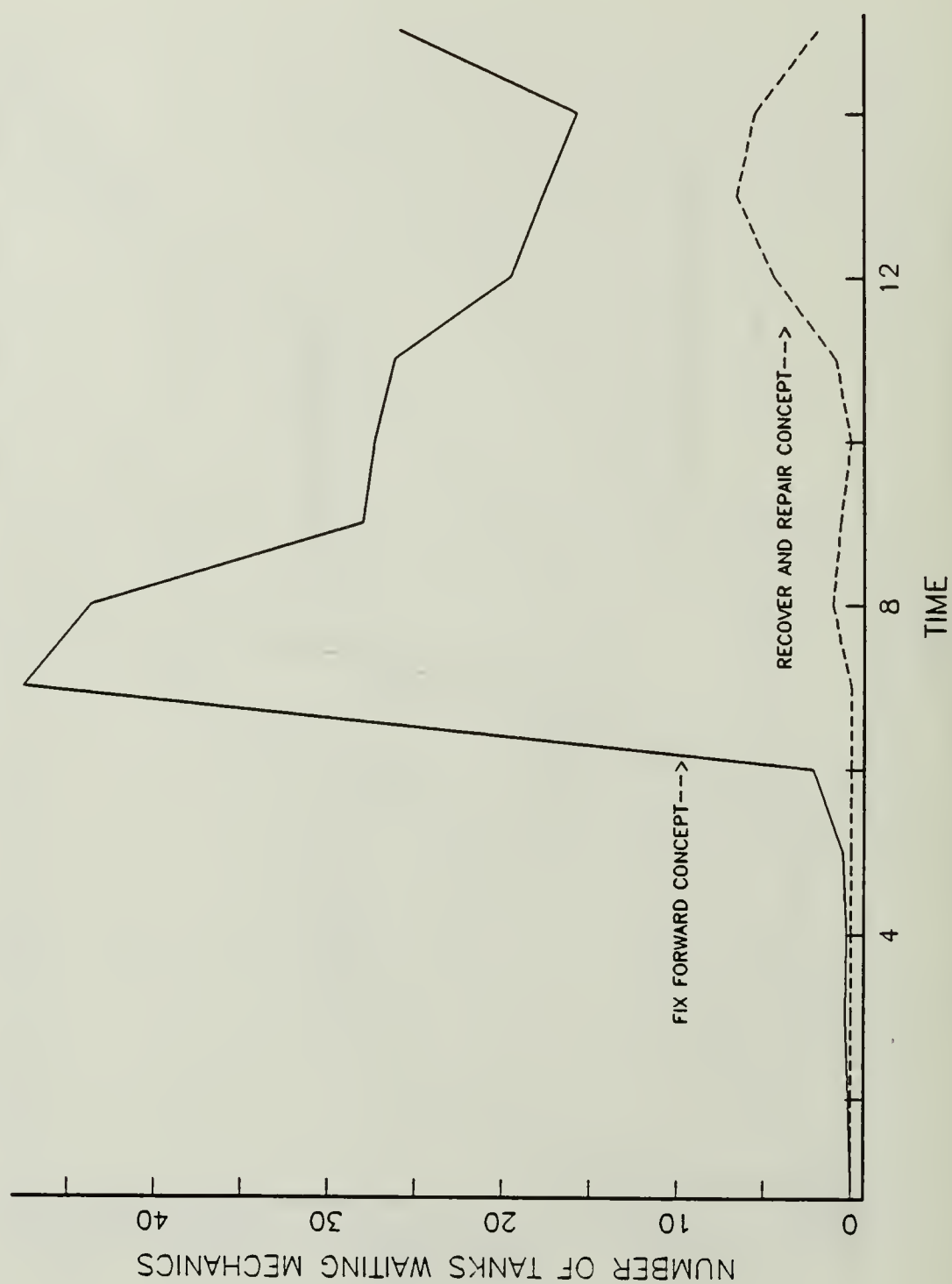


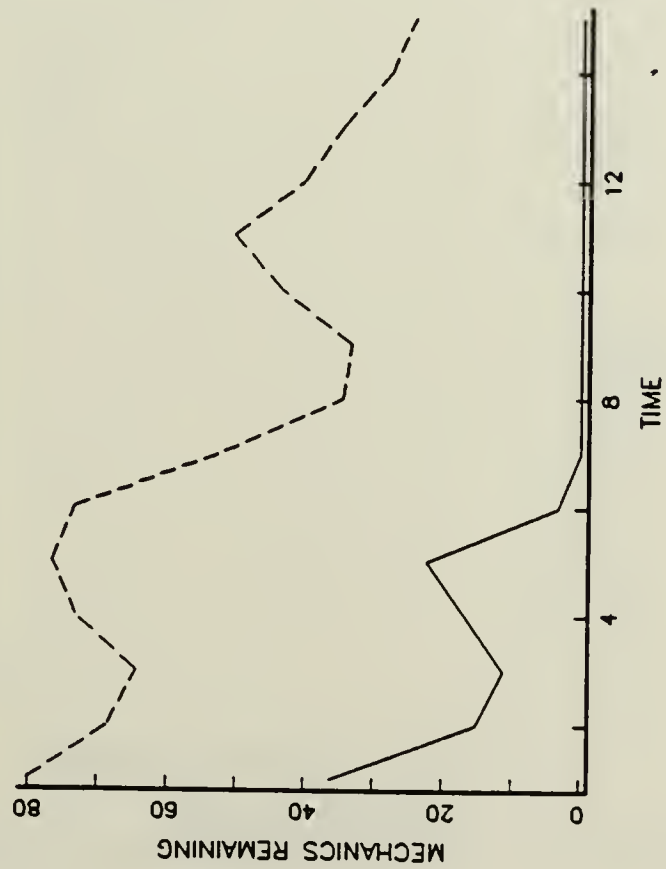
Figure 5.13 Total Waiting Mechanics.

TRACKED VEHICLE MECHANICS

SOLID LINE IS THE FIX FORWARD CONCEPT

DOTTED LINE IS THE RECOVER AND REPAIR CONCEPT

TRACKED VEHICLE MECHANICS REMAINING



TANKS WAITING FOR TRACKED VEHICLE MECHANICS

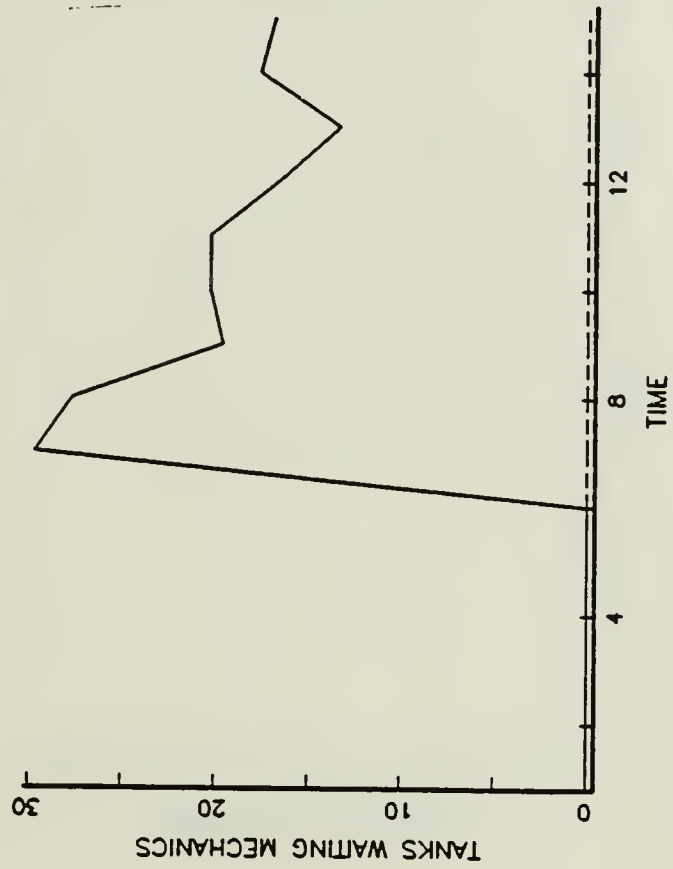
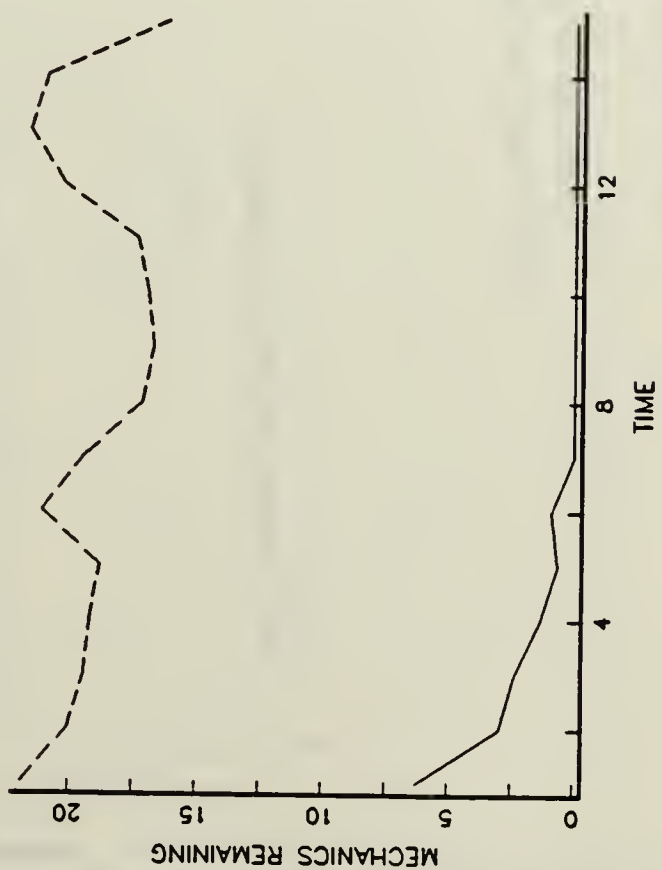


Figure 5.14 Tracked Vehicle Mechanics.

ARMAMENT MECHANICS

SOLID LINE IS THE FIX FORWARD CONCEPT
 DOTTED LINE IS THE RECOVER AND REPAIR CONCEPT

ARMAMENT MECHANICS REMAINING



TANKS WAITING FOR ARMAMENT MECHANICS

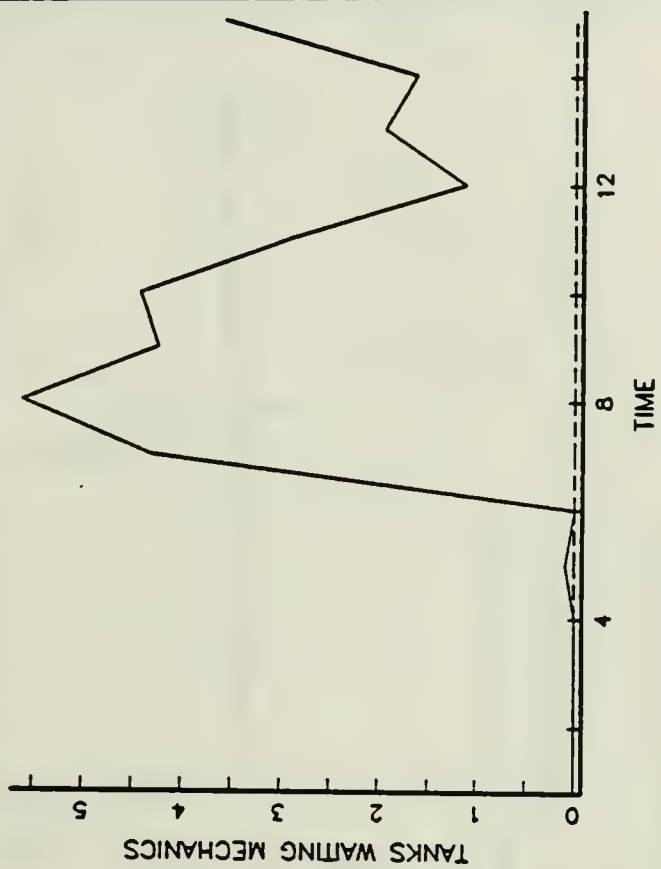
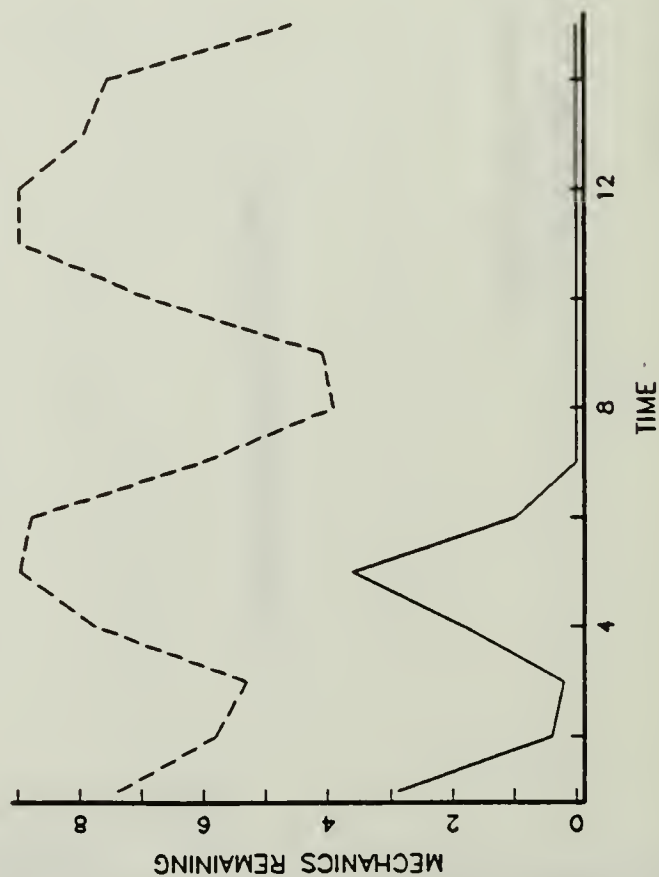


Figure 5.15 Armament Mechanics.

FIRE CONTROL MECHANICS

SOLID LINE IS THE FIX FORWARD CONCEPT
 DOTTED LINE IS THE RECOVER AND REPAIR CONCEPT

FIRE CONTROL MECHANICS REMAINING



TANKS WAITING FOR FIRE CONTROL MECHANICS

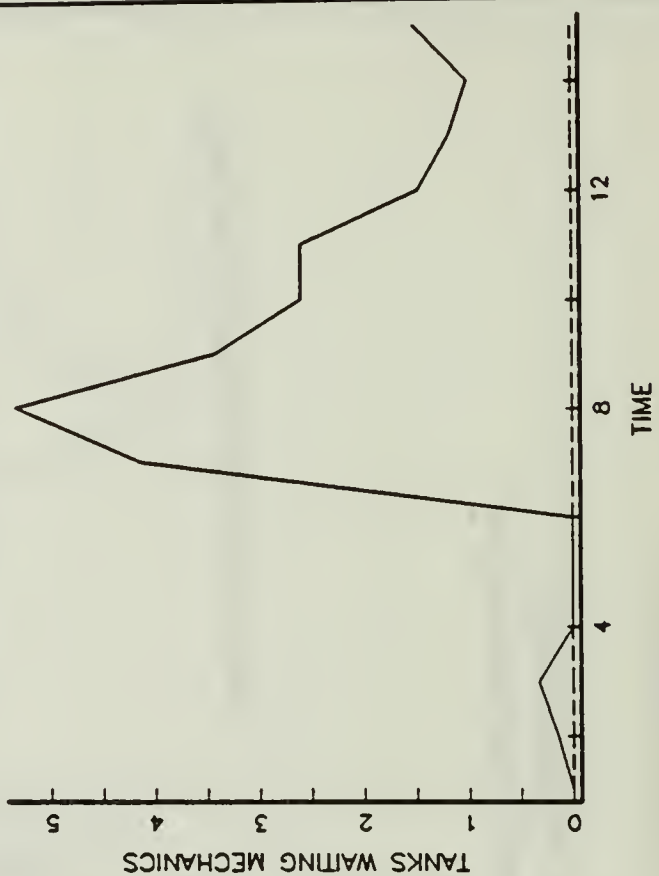
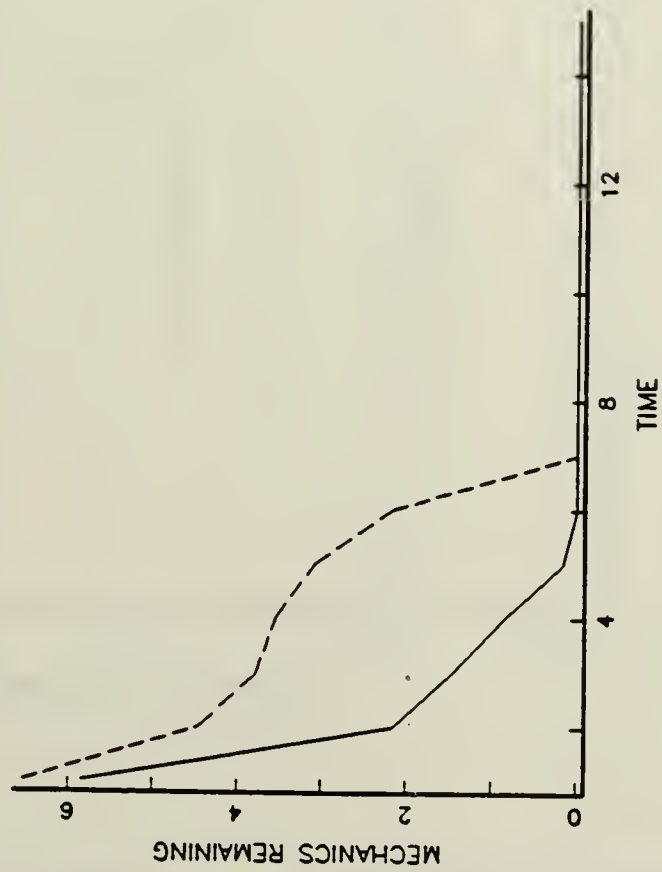


Figure 5.16 Fire Control Mechanics.

ELECTRICAL SYSTEM MECHANICS

SOLID LINE IS THE FIX FORWARD CONCEPT
 DOTTED LINE IS THE RECOVER AND REPAIR CONCEPT

ELECTRICAL SYSTEM MECHANICS REMAINING



TANKS WAITING FOR ELECTRICAL SYSTEM MECHANICS

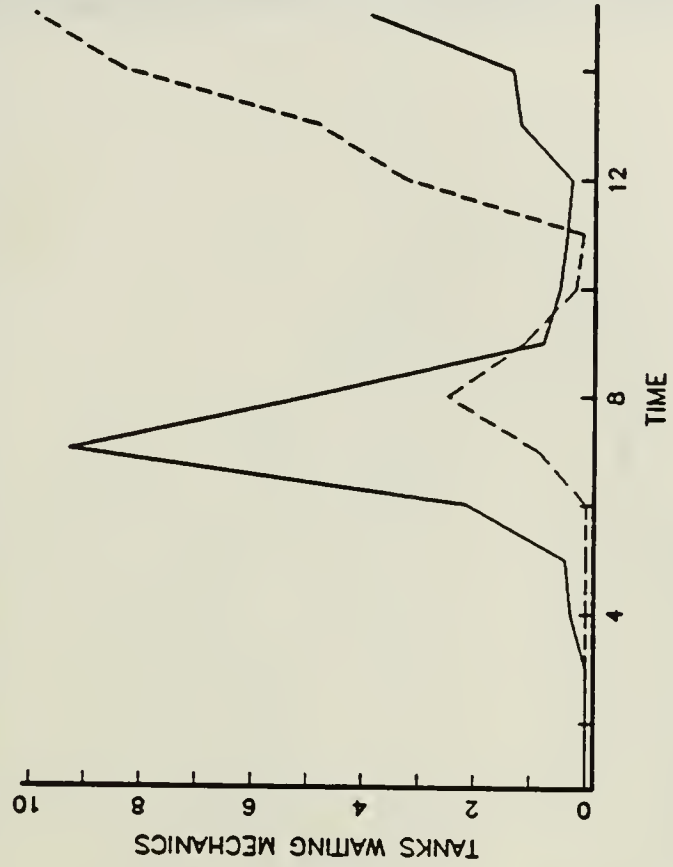


Figure 5.17 Electrical Mechanics.

TOTAL VEHICLES UNDER REPAIR

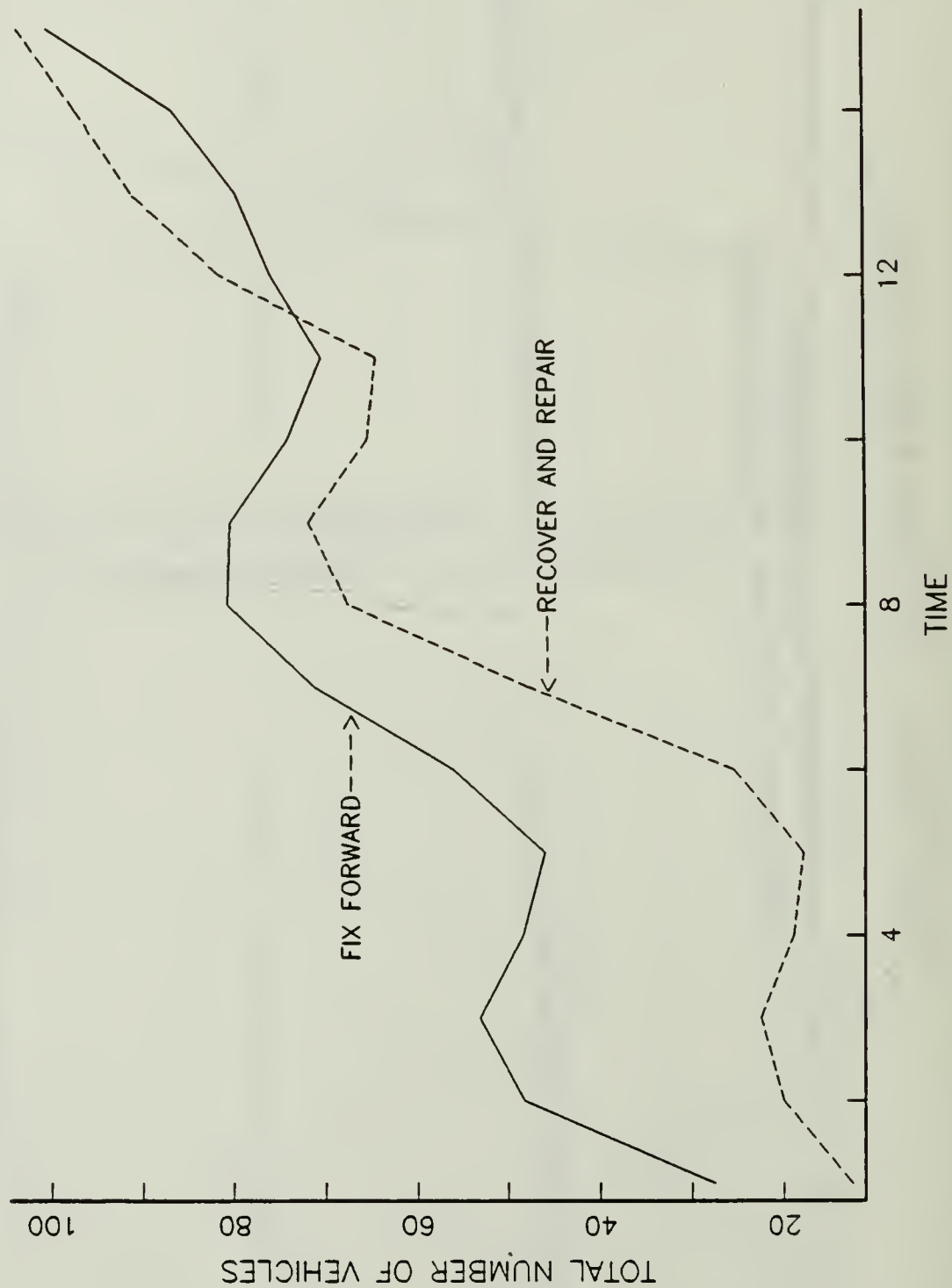


Figure 5.18 Total Vehicles Under Repair.

TANKS IN EVACUATED STATUS AT EACH TIME STEP

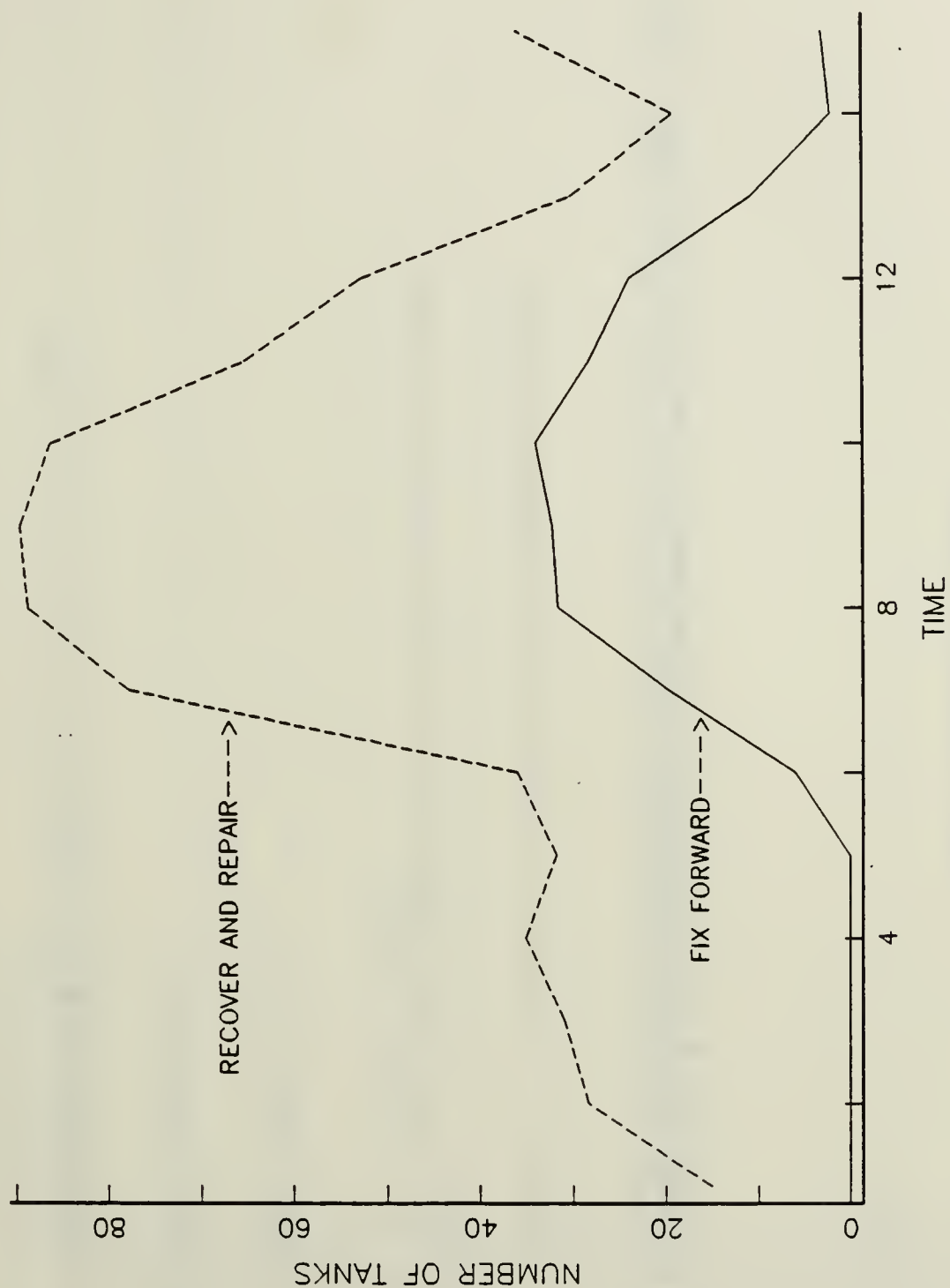


Figure 5.19 Total Vehicles in an Evacuated Status.

APPENDIX A

TANK PROGRAM LISTING

1. INITIALIZATION

The majority of this section has been deleted from this appendix for brevity. This section initialized and defined all the variables and queues that were utilized in this simulation

THESE ARE THE NUMBER OF VEHICLES BY TYPE IN AN ARMORED BRIGADE.

TANKS=162.0

THESE ARE THE INITIAL ON HAND QUANTITIES OF REPAIR PARTS AND THE CALCULATION OF THE REORDER POINTS.

TENG3=100.0
TENG1=40.0
TENG2=40.0
TENG3P=(TENG3+TENG1+TENG2)*0.3
TXMN3=60.0
TXMN1=30.0
TXMN2=30.0
TXMNRP=(TXMN3+TXMN1+TXMN2)*0.3
TXFR3=30.0
TXFR1=20.0
TXFR2=20.0
TXFR3P=(TXFR3+TXFR1+TXFR2)*0.3
TFDR3=50.0
TFDR1=20.0
TFDR2=20.0
TFDR3P=(TFDR3+TFDR1+TFDR2)*0.3
TECN3=30.0
TECN1=20.0
TECN2=20.0
TECN3P=(TECN3+TECN1+TECN2)*0.3
TARM3=30.0
TARM1=20.0
TARM2=20.0

TARMRP=(TARM3+TARM1+TARM2)*0.3
 TELE3=20.0
 TELE1=10.0
 TELE2=10.0
 TELERP=(TELE3+TELE1+TELE2)*0.3
 TTRK3=40.0
 TTRK1=20.0
 TTRK2=20.0
 TTRKRP=(TTRK3+TTRK1+TTRK2)*0.3

THESE ARE THE NUMBER OF MECHANICS AVAILABLE AND THE ALLOWABLE WORKLOAD IN MANHOURS FOR THE TWO MST'S.

TAMEC3=90.0
 TAMEC1=40.0
 TAMEC2=40.0
 TM1AWL=160.0
 TM2AWL=160.0
 ARMEC3=25.0
 ARMEC1=10.0
 ARMEC2=10.0
 AM1AWL=40.0
 AM2AWL=40.0
 ELMEC3=10.0
 ELMEC1=5.0
 ELMEC2=5.0
 EM1AWL=20.0
 EM2AWL=20.0
 FCMEC3=10.0
 FCMEC1=7.0
 FCMEC2=7.0
 FM1AWL=28.0
 FM2AWL=28.0

THESE VALUES ARE THE MECHANICS REQUIRED, THE TIME TO REPAIR EACH TYPE OF DAMAGE AND TOTAL MANHOURS PER JOB.

TENGMR=3.0
 TENGTR=2.5
 TENGMH=7.5
 TXMNMNR=3.0
 TXMNTR=2.5
 TXMNMH=7.5
 TXFRMR=3.0
 TXFTR=2.0
 TXFRMH=6.0
 TTRKMR=2.0
 TTRKTR=8.0
 TTRKMH=16.0
 TEDRMNR=3.0
 TEDRTR=2.5

```

TFDRMH=7.5
TFCNMR=2.0
TFCNTR=3.5
TFCNMH=7.5
TARMMR=2.0
TARMTR=4.5
TARMMH=9.0
TELEMR=2.0
TELETR=9.0
TELEMH=18.0

```

```

DO 11 J=1,15
EVACT1{J}=TIME + 2.0
EVACT2{J}=TIME + 3.0
READ, TANKD1, TANKD2, TANKD3
TIME=TIME+1.0

```

2. EMPIRICAL PROBABILITY DENSITY FUNCTIONS

THE FOLLOWING CALCULATES THE AMOUNT OF DAMAGE PER CATEGORY BY VEHICLE CLASSIFICATION

```

TNKDES=(TANKD1+TANKD2+TANKD3)*0.16471
TENGCD1=TANKD1*0.06353
TXMND1=TANKD1*0.08706
TXFRD1=TANKD1*0.05883
TTRKD1=TANKD1*0.31999
TFDRD1=TANKD1*0.00
TFCND1=TANKD1*0.08706
TARMD1=TANKD1*0.10353
TELED1=TANKD1*0.11529
TENGCD3=TANKD3*0.06353
TXMND3=TANKD3*0.08706
TXFRD3=TANKD3*0.05883
TTRKD3=TANKD3*0.31999
TFDRD3=TANKD3*0.00
TFCND3=TANKD3*0.08706
TARMD3=TANKD3*0.10353
TELED3=TANKD3*0.11529
TENGCD2=TANKD2*0.06353
TXMND2=TANKD2*0.08706
TXFRD2=TANKD2*0.05833
TTRKD2=TANKD2*0.31999

```

```

TEDRD2=TANKD2*0.00
TECND2=TANKD2*0.08706
TARMD2=TANKD2*0.10353
TELED2=TANKD2*0.11529
TANKOR=(TANKS-(TANKD1+TANKD2+TANKD3))/TANKS

```

3. REPAIR AND RETURN QUEUES

This section cycles through the return time queues to determine which vehicle repair jobs have been completed. It then adjusts the total number of vehicles which are under repair and increments the number of mechanics available for repair.

```

IF(J.EQ.1)THEN
GO TO 400
ELSE
N=J-1
END IF
DO 993 K=1,N

```

Tank engines repaired

```

IF(TENRT1(K).LE.TIME)THEN
TENRT1(J)=TENUR1(K)
TEURIT=TEURIT-TENUR1(K)
TERT1=TERT1+TENRR1(J)
TAMEC1=TAMEC1+(TENUR1(K)*TENGMR)
TENUR1(K)=0.0
ELSE
END IF

```

Tank transmissions repaired

```

IF(TXMRRT1(K).LE.TIME)THEN
TXMRRT1(J)=TXMUR1(K)
TXURIT=TXURIT-TXMUR1(K)
TXRT1=TXRT1+TXMRR1(J)
TAMEC1=TAMEC1+(TXMUR1(K)*TXMNMRR)
TXMUR1(K)=0.0
ELSE
END IF

```

Tank transfers repaired

```
IF( TXFRT1(K).LE.TIME)THEN
  TXFRR1(J)=TXFUR1(K)
  TFUR1T=TFUR1T-TXFUR1(K)
  TFRT1=TFRT1+TXFRR1(J)
  TAMEC1=TAMEC1+(TXFUR1(K)*TXFERMR)
  TXFUR1(K)=0.0
ELSE
  END IF
```

Tank final drive repaired

```
IF( TFDRT1(K).LE.TIME)THEN
  TFDRR1(J)=TFDUR1(K)
  TDUR1T=TDUR1T-TFDUR1(K)
  TDRT1=TDRT1+TFDRR1(J)
  TAMEC1=TAMEC1+(TFDUR1(K)*TFDRMR)
  TFDUR1(K)=0.0
ELSE
  END IF
```

Tank track repaired

```
IF( TTRRT1(K).LE.TIME)THEN
  TTRRR1(J)=TTRUR1(K)
  TTUR1T=TTUR1T-TTRUR1(K)
  TTRT1=TTRT1+TTRRR1(J)
  TAMEC1=TAMEC1+(TTRUR1(K)*TTRKMR)
  TTRUR1(K)=0.0
ELSE
  END IF
```

Tank fire control repaired

```
IF( TFCRT1(K).LE.TIME)THEN
  TFCRR1(J)=TFCUR1(K)
  TCUR1T=TCUR1T-TFCUR1(K)
  TCRT1=TCRT1+TFCRR1(J)
  FCMEC1=FCMEC1+(TFCUR1(K)*TFCNMR)
  TFCUR1(K)=0.0
ELSE
  END IF
```

Tank electrical system repaired

```
IF( TELRT1(K).LE.TIME)THEN
  TELRR1(J)=TELUR1(K)
  TLUR1T=TLUR1T-TELUR1(K)
  TLRT1=TLRT1+TELRR1(J)
```

```

        ELMEC1=ELMEC1+(TELUR1(K)*TELEMR)
        TELUR1(K)=0.0
    ELSE
        END IF

```

Tank armament system repaired

```

    IF(TARRT1{K}.LE.TIME)THEN
        TARRR1{J}=TARUR1(K)
        TAUR1T=TAUR1T-TARRR1(K)
        TART1=TART1+TARRR1(J)
        ARMEC1=ARMEC1+(TARUR1(K)*TARMMR)
        TARUR1(K)=0.0
    ELSE
        END IF

```

The remaining code in this format determine the repaired components for MST 2 and the rear DS company

```

    IF(TENRT2{K}.LE.TIME)THEN
        TENRR2{J}=TENUR2(K)
        TEUR2T=TEUR2T-TENUR2(K)
        TERT2=TERT2+TENRR2(J)
        TAMEC2=TAMEC2+(TENUR2(K)*TENGMR)
        TENUR2(K)=0.0
    ELSE
        END IF

```

```

    IF(TXMRT2{K}.LE.TIME)THEN
        TXMRR2{J}=TXMUR2(K)
        TXUR2T=TXUR2T-TXMUR2(K)
        TXRT2=TXRT2+TXMRR2(J)
        TAMEC2=TAMEC2+(TXMUR2(K)*TXMNMNR)
        TXMUR2(K)=0.0
    ELSE
        END IF

```

```

    IF(TXFRT2{K}.LE.TIME)THEN
        TXFRR2{J}=TXFUR2(K)
        TFUR2T=TFUR2T-TXFUR2(K)
        TERT2=TERT2+TXFRR2(J)
        TAMEC2=TAMEC2+(TXFUR2(K)*TXFERMR)
        TXFUR2(K)=0.0
    ELSE
        END IF

```

```

    IF(TEDRT2(K).LE.TIME)THEN

```

```

TFDRR2(J)=TFDUR2(K)
TDUR2T=TDUR2T-TFDUR2(K)
TDRT2=TDRT2+TFDRR2(J)
TAMEC2=TAMEC2+(TFDUR2(K)*TFDRMR)
TFDUR2(K)=0.0
ELSE
END IF

IF( TTRRT2(K).LE.TIME)THEN
TTRRR2{J}=TTRUR2(K)
TTUR2T=TTUR2T-TTRUR2(K)
TTRT2=TTRT2+TTRRR2(J)
TAMEC2=TAMEC2+(TTRUR2(K)*TTRKMR)
TTRUR2(K)=0.0
ELSE
END IF

IF( TFCRT2(K).LE.TIME)THEN
TFCRR2{J}=TFCUR2(K)
TCUR2T=TCUR2T-TFCUR2(K)
TCRT2=TCRT2+TFCRR2(J)
FCMEC2=FCMEC2+(TFCUR2(K)*TFCNMR)
TFCUR2(K)=0.0
ELSE
END IF

IF( TELRT2(K).LE.TIME)THEN
TELRR2{J}=TELUR2(K)
TLUR2T=TLUR2T-TELUR2(K)
TLRT2=TLRT2+TELRR2(J)
ELMEC2=ELMEC2+(TELUR2(K)*TELEMR)
TELUR2(K)=0.0
ELSE
END IF

IF( TARRT2(K).LE.TIME)THEN
TARRR2{J}=TARUR2(K)
TAUR2T=TAUR2T-TARRR2(K)
TART2=TART2+TARRR2(J)
ARMEC2=ARMEC2+(TARUR2(K)*TARMMR)
TARUR2(K)=0.0
ELSE
END IF

IF( TENRT3(K).LE.TIME)THEN

```

```

TENRR3(J)=TENUR3(K)
TEUR3T=TEUR3T-TENUR3(K)
TERT3=TERT3+TENRR3(J)
TAMEC3=TAMEC3+(TENUR3(K)*TENGMR)
TENUR3(K)=0.0
ELSE
END IF

```

```

IF(TXMRT3(K).LE.TIME)THEN
TXMRR3(J)=TXMUR3(K)
TXUR3T=TXUR3T-TXMUR3(K)
TXRT3=TXRT3+TXMRR3(J)
TAMEC3=TAMEC3+(TXMUR3(K)*TXMNMNR)
TXMUR3(K)=0.0
ELSE
END IF

```

```

IF(TXFERT3(K).LE.TIME)THEN
TXFERR3(J)=TXFUR3(K)
TFUR3T=TFUR3T-TXFUR3(K)
TFRT3=TFRT3+TXFERR3(J)
TAMEC3=TAMEC3+(TXFUR3(K)*TXFRMR)
TXFUR3(K)=0.0
ELSE
END IF

```

```

IF(TEDRT3(K).LE.TIME)THEN
TEDRR3(J)=TFDUR3(K)
TDUR3T=TDUR3T-TFDUR3(K)
TDRT3=TDRT3+TFDRR3(J)
TAMEC3=TAMEC3+(TFDUR3(K)*TFDRMR)
TFDUR3(K)=0.0
ELSE
END IF

```

```

IF(TTRRT3(K).LE.TIME)THEN
TTRRR3(J)=TTRUR3(K)
TTUR3T=TTUR3T-TTRUR3(K)
TTRT3=TTRT3+TTRRR3(J)
TAMEC3=TAMEC3+(TTRUR3(K)*TTRKMR)
TTRUR3(K)=0.0
ELSE
END IF

```

```

IF(TECRT3(K).LE.TIME)THEN
TECRR3(J)=TECUR3(K)

```

```

TCUR3T=TCUR3T-TFCUR3(K)
TCRT3=TCRT3+TFCRR3(J)
FCMEC3=FCMEC3+(TFCUR3(K)*TFCNMR)
TFCUR3(K)=0.0
ELSE
END IF

IF( TELRT3(K).LE.TIME)THEN
TELRR3{J}=TELUR3(K)
TLUR3T=TLUR3T-TELUR3(K)
TLRT3=TLRT3+TELRR3(J)
ELMEC3=ELMEC3+(TELUR3(K)*TELEMR)
TELUR3(K)=0.0
ELSE
END IF

IF( TARRT3(K).LE.TIME)THEN
TARRR3{J}=TARUR3(K)
TAUR3T=TAUR3T-TARUR3(K)
TART3=TART3+TARRR3(J)
ARMEC3=ARMEC3+(TARUR3(K)*TARMMR)
TARUR3(K)=0.0
ELSE
END IF

993 CONTINUE

```

4. WAITING MECHANIC QUEUES

These are the routines that cycle through the waiting mechanic queues and the mechanic availability to determine if vehicles that had been in a waiting mechanic status can transfer to an under repair status.

```

400 IF(J.EQ.1)THEN
GO TO 401
ELSE
L=J-1
END IF
DO 991 K=1,L

```

Tank engines waiting mechanics

```

IF(TENWML(K).GT.0.0)THEN
  TENML=TENWML(K)*TENGMR
ELSE
  GO TO 100
END IF
IF(TAMEC1.GT.0.0)THEN
  RATIO=TTENML/TAMEC1
ELSE
  GO TO 100
END IF
IF(RATIO.LE.1.0)THEN
  TENUR1(J)=TENUR1(J)+TENWML(K)
  TAMEC1=TAMEC1-TTENML
  TEWM1T=TEWM1T-TENWML(K)
  TENWML(K)=0.0
ELSE
  TENUR1(J)=TENUR1(J)+(TENWML(K)/RATIO)
  TEWM1T=TEWM1T-(TENWML(K)/RATIO)
  TENWML(K)=TENWML(K)-(TENWML(K)/RATIO)
  TAMEC1=0.0
ENDIF

```

Tank transmissions waiting mechanics

```

100 IF(TXMMWML(K).GT.0.0)THEN
  TTXMMML=TXMMWML(K)*TXMNMNR
ELSE
  GO TO 101
END IF
IF(TAMEC1.GT.0.0)THEN
  RATIO=TTXMMML/TAMEC1
ELSE
  GO TO 101
END IF
IF(RATIO.LE.1.0)THEN
  TXMUR1(J)=TXMUR1(J)+TXMMWML(K)
  TAMEC1=TAMEC1-TTXMMML
  TXWM1T=TXWM1T-TXMMWML(K)
  TXMMWML(K)=0.0
ELSE
  TXMUR1(J)=TXMUR1(J)+(TXMMWML(K)/RATIO)
  TXWM1T=TXWM1T-(TXMMWML(K)/RATIO)
  TXMMWML(K)=TXMMWML(K)-(TXMMWML(K)/RATIO)
  TAMEC1=0.0
ENDIF

```

Tank transfers waiting mechanics

```

101 IF(TXFEWML(K).GT.0.0)THEN

```

```

    TTXFWM1=TXFWM1(K)*TXFRMR
    ELSE
    GO TO 102
    END IF
    IF(TAMEC1.GT.0.0)THEN
    RATIO=TTXFWM1/TAMEC1
    ELSE
    GO TO 102
    END IF
    IF(RATIO.LE.1.0)THEN
    TXFUR1(J)=TXFUR1(J)+TXFWM1(K)
    TAMEC1=TAMEC1-TTXFWM1
    TFWM1T=TFWM1T-TXFWM1(K)
    TXFWM1(K)=0.0
    ELSE
    TXFUR1(J)=TXFUR1(J)+(TXFWM1(K)/RATIO)
    TFWM1T=TFWM1T-(TXFWM1(K)/RATIO)
    TXFWM1(K)=TXFWM1(K)-(TXFWM1(K)/RATIO)
    TAMEC1=0.0
    ENDIF

```

Tank track waiting mechanics

```

102  IF(TTRWM1(K).GT.0.0)THEN
    ELSE
    GO TO 123
    END IF
    IF(TAMEC1.GT.0.0)THEN
    RATIO=TTTRM1/TAMEC1
    ELSE
    GO TO 123
    END IF
    IF(RATIO.LE.1.0)THEN
    TTRUR1(J)=TTRUR1(J)+TTRWM1(K)
    TAMEC1=TAMEC1-TTTRM1
    TTWM1T=TTWM1T-TTRWM1(K)
    TTRWM1(K)=0.0
    ELSE
    TTRUR1(J)=TTRUR1(J)+(TTRWM1(K)/RATIO)
    TTWM1T=TTWM1T-(TTRWM1(K)/RATIO)
    TTRWM1(K)=TTRWM1(K)-(TTRWM1(K)/RATIO)
    TAMEC1=0.0
    ENDIF

```

Tank final drive waiting mechanic

```

123  IF(TFDWM1(K).GT.0.0)THEN
    ELSE
    TTFDM1=TFDWM1(K)*TFDRMR

```

```

GO TO 108
END IF
  IF(TAMEC1.GT.0.0) THEN
    RATIO=TFEDM1/TAMEC1
  ELSE
    GO TO 108
  END IF
  IF(RATIO.LE.1.0) THEN
    TEDUR1(J)=TEDUR1(J)+TFDWM1(K)
    TAMEC1=TAMEC1-TTFEDM1
    TDWM1T=TDWM1T-TTFDWM1(K)
    TFDWM1(K)=0.0
  ELSE
    TEDUR1(J)=TEDUR1(J)+(TFDWM1(K)/RATIO)
    TDWM1T=TDWM1T-(TFDWM1(K)/RATIO)
    TFDWM1(K)=TFDWM1(K)-(TFDWM1(K)/RATIO)
    TAMEC1=0.0
  ENDIF

```

Tank armament waiting mechanics

```

108  IF(TARWM1(K).GT.0.0) THEN
      TTARM1=TARM1(K)*TARMMR
    ELSE
      GO TO 110
    END IF
    IF(ARMEC1.GT.0.0) THEN
      RATIO=TTARM1/ARMEC1
    ELSE
      GO TO 110
    END IF
    IF(RATIO.LE.1.0) THEN
      TARUR1(J)=TARUR1(J)+TARWM1(K)
      ARMEC1=ARMEC1-TTARM1
      TAWM1T=TAWM1T-TARWM1(K)
      TARWM1(K)=0.0
    ELSE
      TARUR1(J)=TARUR1(J)+(TARWM1(K)/RATIO)
      TAWM1T=TAWM1T-(TARWM1(K)/RATIO)
      TARWM1(K)=TARWM1(K)-(TARWM1(K)/RATIO)
      ARMEC1=0.0
    ENDIF

```

Tank electrical waiting mechanics

```

110  IF(TELM1(K).GT.0.0) THEN
      TTELM1=TELM1(K)*TELEMR
    ELSE
      GO TO 112
    END IF

```

```

IF(ELMEC1.GT.0.0)THEN
  RATIO=TTELM1/ELMEC1
ELSE
  GO TO 112
END IF
IF(RATIO.LE.1.0)THEN
  TELUR1(J)=TELUR1(J)+TELWM1(K)
  ELMEC1=ELMEC1-TTELM1
  TLWM1T=TLWM1T-TELWM1(K)
  TELWM1(K)=0.0
ELSE
  TELUR1(J)=TELUR1(J)+(TELWM1(K)/RATIO)
  TLWM1T=TLWM1T-(TELWM1(K)/RATIO)
  TELWM1(K)=TELWM1(K)-(TELWM1(K)/RATIO)
  ELMEC1=0.0
ENDIF

```

Tank fire control waiting mechanics

```

112 IF(TFCWM1(K).GT.0.0)THEN
  TTECM1=TFCWM1(K)*TFCNMR
ELSE
  GO TO 114
END IF
IF(ECMEC1.GT.0.0)THEN
  RATIO=TTECM1/ECMEC1
ELSE
  GO TO 114
END IF
IF(RATIO.LE.1.0)THEN
  TECUR1(J)=TECUR1(J)+TFCWM1(K)
  ECMEC1=ECMEC1-TTECM1
  TCWM1T=TCWM1T-TFCWM1(K)
  TFCWM1(K)=0.0
ELSE
  TECUR1(J)=TECUR1(J)+(TFCWM1(K)/RATIO)
  TCWM1T=TCWM1T-(TFCWM1(K)/RATIO)
  TFCWM1(K)=TFCWM1(K)-(TFCWM1(K)/RATIO)
  ECMEC1=0.0
ENDIF

```

This section of code is for the components damaged that are waiting mechanics at MST 2 and the rear DS company

```

114 IF(TENWM2(K).GT.0.0)THEN
  TTENM2=TENWM2(K)*TENGMR
ELSE
  GO TO 119
END IF
IF(TAMEC2.GT.0.0)THEN

```

```

        RATIO=TTENM2/TAMEC2
    ELSE
        GO TO 119
    END IF
    IF(RATIO.LE.1.0)THEN
        TENUR2(J)=TENUR2(J)+TENWM2(K)
        TAMEC2=TAMEC2-TTENM2
        TEWM2T=TEWM2T-TENWM2(K)
        TENWM2(K)=0.0
    ELSE
        TENUR2(J)=TENUR2(J)+(TENWM2(K)/RATIO)
        TEWM2T=TEWM2T-(TENWM2(K)/RATIO)
        TENWM2(K)=TENWM2(K)-(TENWM2(K)/RATIO)
        TAMEC2=0.0
    ENDIF

119  IF(TXMMWM2(K).GT.0.0)THEN
        TTXMM2=TXMMWM2(K)*TXMNM2
    ELSE
        GO TO 120
    END IF
    IF(TAMEC2.GT.0.0)THEN
        RATIO=TTXMM2/TAMEC2
    ELSE
        GO TO 120
    END IF
    IF(RATIO.LE.1.0)THEN
        TXMUR2(J)=TXMUR2(J)+TXMMWM2(K)
        TAMEC2=TAMEC2-TTXMM2
        TXWM2T=TXWM2T-TXMMWM2(K)
        TXMMWM2(K)=0.0
    ELSE
        TXMUR2(J)=TXMUR2(J)+(TXMMWM2(K)/RATIO)
        TXWM2T=TXWM2T-(TXMMWM2(K)/RATIO)
        TXMMWM2(K)=TXMMWM2(K)-(TXMMWM2(K)/RATIO)
        TAMEC2=0.0
    ENDIF

120  IF(TXFWWM2(K).GT.0.0)THEN
        TTXFM2=TXFWWM2(K)*TXFRMR
    ELSE
        GO TO 121
    END IF
    IF(TAMEC2.GT.0.0)THEN
        RATIO=TTXFM2/TAMEC2
    ELSE
        GO TO 121
    END IF

```

```

IF(RATIO.LE.1.0)THEN
  TXFUR2(J)=TXFUR2(J)+TXFWM2(K)
  TAMEC2=TAMEC2-TTXFM2
  TFWM2T=TFWM2T-TXFWM2(K)
  TXFWM2(K)=0.0
ELSE
  TXFUR2(J)=TXFUR2(J)+(TXFWM2(K)/RATIO)
  TFWM2T=TFWM2T-(TXFWM2(K)/RATIO)
  TXFWM2(K)=TXFWM2(K)-(TXFWM2(K)/RATIO)
  TAMEC2=0.0
ENDIF

```

```

121 IF(TTRWM2(K).GT.0.0)THEN
  TTRM2=TTRWM2(K)*TTRKMR
ELSE
  GO TO 122
END IF
  IF(TAMEC2.GT.0.0)THEN
    RATIO=TTRM2/TAMEC2
  ELSE
    GO TO 122
  END IF
  IF(RATIO.LE.1.0)THEN
    TTRUR2(J)=TTRUR2(J)+TTRWM2(K)
    TAMEC2=TAMEC2-TTTRM2
    TTWM2T=TTWM2T-TTRWM2(K)
    TTRWM2(K)=0.0
  ELSE
    TTRUR2(J)=TTRUR2(J)+(TTRWM2(K)/RATIO)
    TTWM2T=TTWM2T-(TTRWM2(K)/RATIO)
    TTRWM2(K)=TTRWM2(K)-(TTRWM2(K)/RATIO)
    TAMEC2=0.0
  ENDIF

```

```

122 IF(TFDWM2(K).GT.0.0)THEN
  TTFDM2=TFDWM2(K)*TFDRMR
ELSE
  GO TO 130
END IF
  IF(TAMEC2.GT.0.0)THEN
    RATIO=TTFDM2/TAMEC2
  ELSE
    GO TO 130
  END IF
  IF(RATIO.LE.1.0)THEN
    TFDUR2(J)=TFDUR2(J)+TFDWM2(K)
    TAMEC2=TAMEC2-TTFDM2
    TDFWM2T=TDFWM2T-TFDWM2(K)

```

```

ELSE
    TFDWM2(K)=0.0
    TFDUR2(J)=TFDUR2(J)+(TFDWM2(K)/RATIO)
    TDWM2T=TDWM2T-(TFDWM2(K)/RATIO)
    TFDWM2(K)=TFDWM2(K)-(TFDWM2(K)/RATIO)
    TAMEC2=0.0
ENDIF

130 IF(TARWM2(K).GT.0.0)THEN
    TTARM2=TARWM2(K)*TARMMR
ELSE
    GO TO 132
END IF
    IF(ARMEC2.GT.0.0)THEN
        RATIO=TTARM2/ARMEC2
    ELSE
        GO TO 132
    END IF
        IF(RATIO.LE.1.0)THEN
            TARUR2(J)=TARUR2(J)+TARWM2(K)
            ARMEC2=ARMEC2-TTARM2
            TAWM2T=TAWM2T-TARWM2(K)
            TARWM2(K)=0.0
        ELSE
            TARUR2(J)=TARUR2(J)+(TARWM2(K)/RATIO)
            TAWM2T=TAWM2T-(TARWM2(K)/RATIO)
            TARWM2(K)=TARWM2(K)-(TARWM2(K)/RATIO)
            ARMEC2=0.0
        ENDIF

132 IF(TELMW2(K).GT.0.0)THEN
    TTELM2=TELMW2(K)*TELEMR
ELSE
    GO TO 134
END IF
    IF(ELMEC2.GT.0.0)THEN
        RATIO=TTELM2/ELMEC2
    ELSE
        GO TO 134
    END IF
        IF(RATIO.LE.1.0)THEN
            TELUR2(J)=TELUR2(J)+TELMW2(K)
            ELMEC2=ELMEC2-TTELM2
            TLWM2T=TLWM2T-TELMW2(K)
            TELWM2(K)=0.0
        ELSE
            TELUR2(J)=TELUR2(J)+(TELMW2(K)/RATIO)
            TLWM2T=TLWM2T-(TELMW2(K)/RATIO)

```

```

      TELWM2(K)=TELWM2(K)- ( TELWM2(K)/RATIO)
      ELMEC2=0.0
    ENDIF

134  IF( TFCWM2(K).GT.0.0)THEN
      TTFCM2=TFCWM2(K)*TFCNMR
    ELSE
      GO TO 136
    END IF
      IF(FCMEC2.GT.0.0)THEN
        RATIO=TTFCM2/FCMEC2
      GO TO 136
    END IF
      IF(RATIO.LE.1.0)THEN
        TFCUR2(J)=TFCUR2(J)+TFCWM2(K)
        FCMEC2=FCMEC2-TTFCM2
        TCWM2T=TCWM2T-TFCWM2(K)
        TFCWM2(K)=0.0
      ELSE
        TFCUR2(J)=TFCUR2(J)+( TFCWM2(K)/RATIO)
        TCWM2T=TCWM2T-( TFCWM2(K)/RATIO)
        TFCWM2(K)=TFCWM2(K)-( TFCWM2(K)/RATIO)
        FCMEC2=0.0
      ENDIF

136  IF(TENWM3(K).GT.0.0)THEN
      TTENM3=TENWM3(K)*TENGMR
    ELSE
      GO TO 137
    END IF
      IF(TAMEC3.GT.0.0)THEN
        RATIO=TTENM3/TAMEC3
      ELSE
        GO TO 137
      END IF
      IF(RATIO.LE.1.0)THEN
        TENUR3(J)=TENUR3(J)+TENWM3(K)
        TAMEC3=TAMEC3-TTENM3
        TEWM3T=TEWM3T-TENWM3(K)
        TENWM3(K)=0.0
      ELSE
        TENUR3(J)=TENUR3(J)+( TENWM3(K)/RATIO)
        TEWM3T=TEWM3T-( TENWM3(K)/RATIO)
        TENWM3(K)=TENWM3(K)-( TENWM3(K)/RATIO)
        TAMEC3=0.0
      ENDIF

```

```

137 IF(TXMMW3(K).GT.0.0)THEN
      TTXMM3=TXMMW3(K)*TXMNM3R
    ELSE
      GO TO 138
    END IF
    IF(TAMEC3.GT.0.0)THEN
      RATIO=TTXMM3/TAMEC3
    ELSE
      GO TO 138
    END IF
    IF(RATIO.LE.1.0)THEN
      TXMUR3(J)=TXMUR3(J)+TXMMW3(K)
      TAMEC3=TAMEC3-TTXMM3
      TXWM3T=TXWM3T-TXMMW3(K)
      TXMMW3(K)=0.0
    ELSE
      TXMUR3(J)=TXMUR3(J)+(TXMMW3(K)/RATIO)
      TXWM3T=TXWM3T-(TXMMW3(K)/RATIO)
      TXMMW3(K)=TXMMW3(K)-(TXMMW3(K)/RATIO)
      TAMEC3=0.0
    ENDIF

138 IF(TXFWM3(K).GT.0.0)THEN
      TTXFM3=TXFWM3(K)*TXFERMR
    ELSE
      GO TO 139
    END IF
    IF(TAMEC3.GT.0.0)THEN
      RATIO=TTXFM3/TAMEC3
    ELSE
      GO TO 139
    END IF
    IF(RATIO.LE.1.0)THEN
      TXFUR3(J)=TXFUR3(J)+TXFWM3(K)
      TAMEC3=TAMEC3-TTXFM3
      TFWM3T=TFWM3T-TXFWM3(K)
      TXFWM3(K)=0.0
    ELSE
      TXFUR3(J)=TXFUR3(J)+(TXFWM3(K)/RATIO)
      TFWM3T=TFWM3T-(TXFWM3(K)/RATIO)
      TXFWM3(K)=TXFWM3(K)-(TXFWM3(K)/RATIO)
      TAMEC3=0.0
    ENDIF

139 IF(TTRWM3(K).GT.0.0)THEN
      TTTRM3=TTRWM3(K)*TTRKMR
    ELSE
      GO TO 140

```

```

END IF
  IF (TAMEC3.GT.0.0) THEN
    RATIO=TTTRM3/TAMEC3
  ELSE
    GO TO 140
  END IF
  IF (RATIO.LE.1.0) THEN
    TTRUR3(J)=TTRUR3(J)+TTRWM3(K)
    TAMEC3=TAMEC3-TTTRM3
    TTWM3T=TTWM3T-TTRWM3(K)
    TTRWM3(K)=0.0
  ELSE
    TTRUR3(J)=TTRUR3(J)+(TTRWM3(K)/RATIO)
    TTWM3T=TTWM3T-(TTRWM3(K)/RATIO)
    TTRWM3(K)=TTRWM3(K)-(TTRWM3(K)/RATIO)
    TAMEC3=0.0
  ENDIF

140 IF (TFEDWM3(K).GT.0.0) THEN
  TTFEDM3=TFEDWM3(K)*TFDRMR
  ELSE
    GO TO 141
  END IF
  IF (TAMEC3.GT.0.0) THEN
    RATIO=TTFDM3/TAMEC3
  ELSE
    GO TO 141
  END IF
  IF (RATIO.LE.1.0) THEN
    TFEDUR3(J)=TFEDUR3(J)+TFDWM3(K)
    TAMEC3=TAMEC3-TTFDM3
    TDWM3T=TDWM3T-TFDWM3(K)
    TFDWM3(K)=0.0
  ELSE
    TFEDUR3(J)=TFEDUR3(J)+(TFDWM3(K)/RATIO)
    TDWM3T=TDWM3T-(TFDWM3(K)/RATIO)
    TFDWM3(K)=TFDWM3(K)-(TFDWM3(K)/RATIO)
    TAMEC3=0.0
  ENDIF

141 IF (TARWM3(K).GT.0.0) THEN
  TTARM3=TARWM3(K)*TARMMR
  ELSE
    GO TO 142
  END IF
  IF (ARMEC3.GT.0.0) THEN
    RATIO=TTARM3/ARMEC3
  ELSE

```

```

GO TO 142
END IF
IF(RATIO.LE.1.0)THEN
TARUR3(J)=TARUR3(J)+TARWM3(K)
ARMEC3=ARMEC3-TTARM3
TAWM3T=TAWM3T-TARWM3(K)
TARWM3(K)=0.0
ELSE
TARUR3(J)=TARUR3(J)+(TARWM3(K)/RATIO)
TAWM3T=TAWM3T-(TARWM3(K)/RATIO)
TARWM3(K)=TARWM3(K)-(TARWM3(K)/RATIO)
ARMEC3=0.0
ENDIF

142 IF(TELMW3(K).GT.0.0)THEN
TTELM3=TELMW3(K)*TELMR
ELSE
GO TO 144
END IF
IF(ELMEC3.GT.0.0)THEN
RATIO=TTELM3/ELMEC3
ELSE
GO TO 144
END IF
IF(RATIO.LE.1.0)THEN
TELUR3(J)=TELUR3(J)+TELMW3(K)
ELMEC3=ELMEC3-TTELM3
TLWM3T=TLWM3T-TELMW3(K)
TELMW3(K)=0.0
ELSE
TELUR3(J)=TELUR3(J)+(TELMW3(K)/RATIO)
TLWM3T=TLWM3T-(TELMW3(K)/RATIO)
TELMW3(K)=TELMW3(K)-(TELMW3(K)/RATIO)
ELMEC3=0.0
ENDIF

144 IF(TECWM3(K).GT.0.0)THEN
TTFCM3=TEFCWM3(K)*TFCNMR
ELSE
GO TO 146
END IF
IF(FCMEC3.GT.0.0)THEN
RATIO=TTFCM3/FCMEC3
ELSE
GO TO 146
END IF
IF(RATIO.LE.1.0)THEN
TEFCUR3(J)=TEFCUR3(J)+TEFCWM3(K)

```

```

FCMEC3=FCMEC3-TTFCM3
TCWM3T=TCWM3T-TFCWM3(K)
TFCWM3(K)=0.0
ELSE
    TFCUR3(J)=TFCUR3(J)+(TFCWM3(K)/RATIO)
    TCWM3T=TCWM3T-(TFCWM3(K)/RATIO)
    TFCWM3(K)=TFCWM3(K)-(TFCWM3(K)/RATIO)
    FCMEC3=0.0
ENDIF
991 CONTINUE

```

5. QUEUE ALLOCATION ROUTINES

This routine takes the data from the empirical distribution function and makes the initial assignments to the three major queues; under repair, waiting parts or waiting mechanics.

Tank engine

```

401 TOTAL=TENG1+TENUR1(J)
    IF(TOTAL.EQ.0.0)GO TO 1
    IF(TENG1.LE.TENG1)THEN
        TENWR1=TOTAL
        TENG1=TENG1-TENG1
    ELSE
        TENWR1=TENG1
        TENWP1(J)=TENG1-TENG1
        TENG1=0.0
    END IF
    TTENM1=TENWR1*TENGMR
    IF(TTENM1.LE.TAMEC1)THEN
        TENUR1(J)=TENUR1(J)+TENWR1
        TAMEC1=TAMEC1-TTENM1
    ELSE
        TENUR1(J)=TENUR1(J)+(TAMEC1/TTENM1)*TENWR1
        TENWM1(J)=TENWM1(J)+TENG1-(TAMEC1/TTENM1)*TENWR1-TENWP1(J)
        TAMEC1=0.0
    END IF
    TENRT1(J)=TIME+TENGTR
    TEUR1T=TEUR1T+TENUR1(J)
    TEWP1T=TEWP1T+TENWP1(J)

```

```

1  TEWM1T=TEWM1T+TENWM1(J)
   TENWL1=TEWM1T*TENGMMH
   TOTAL=TENG2+TENUR2(J)
   IF(TOTAL.EQ.0.0)GO TO 2
   IF(TENG2.LE.TENG2) THEN
     TENWR2=TENG2
     TENG2=TENG2-TENG2
   ELSE
     TENWR2=TENG2
     TENWP2(J)=TENG2-TENG2
     TENG2=0.0
   END IF
   TTENM2=TENWR2*TENGMMR
   IF(TTENM2.LE.TAMEC2) THEN
     TENUR2(J)=TENUR2(J)+TENWR2
     TAMEC2=TAMEC2-TTENM2
   ELSE
     TENUR2(J)=TENUR2(J)+(TAMEC2/TTENM2)*TENWR2
     TENWM2{J}=TENWM2{J}+TENG2-(TAMEC2/TTENM2)*TENWR2-TENWP2(J)
     TAMEC2=0.0
   END IF
   TENRT2(J)=TIME+TENGTR
   TEUR2T=TEUR2T+TENUR2{J}
   TEWP2T=TEWP2T+TENWP2{J}
   TEWM2T=TEWM2T+TENWM2{J}
   TENWL2=TEWM2T*TENGMMH

2  TENG3=TENG3+ETWR1+ETWR2
   TOTAL=TENG3+TENUR3(J)
   IF(TOTAL.EQ.0.0)GO TO 3
   IF(TENG3.LE.TENG3) THEN
     TENWR3=TENG3
     TENG3=TENG3-TENG3
   ELSE
     TENWR3=TENG3
     TENWP3(J)=TENG3-TENG3
     TENG3=0.0
   END IF
   TTENM3=TENWR3*TENGMMR
   IF(TTENM3.LE.TAMEC3) THEN
     TENUR3(J)=TENUR3(J)+TENWR3
     TAMEC3=TAMEC3-TTENM3
   ELSE
     TENUR3(J)=TENUR3(J)+(TAMEC3/TTENM3)*TENWR3
     TENWM3{J}=TENWM3{J}+TENG3-(TAMEC3/TTENM3)*TENWR3-TENWP3(J)
     TAMEC3=0.0
   END IF
   TENRT3(J)=TIME+TENGTR

```

```
TEUR3T=TEUR3T+TENUR3(J)
TEWP3T=TEWP3T+TENWP3(J)
TEWM3T=TEWM3T+TENWM3(J)
TENWL3=TEWM3T*TENGMMH
```

Tank transmissions

3

```
TOTAL=TXMND1+TXMUR1(J)
IF(TOTAL.EQ.0.0)GO TO 4
IF(TXMND1.LE.TXMN1)THEN
  TXMWR1=TXMND1
  TXMN1=TXMN1-TXMND1
ELSE
  TXMWR1=TXMN1
  TXMWP1(J)=TXMND1-TXMN1
  TXMN1=0.0
END IF
TTXMM1=TXMWR1*TXMNMNR
IF(TTXMM1.LE.TAMEC1)THEN
  TXMUR1(J)=TXMUR1(J)+TXMWR1
  TAMEC1=TAMEC1-TTXMM1
ELSE
  TXMUR1(J)=TXMUR1(J)+(TAMEC1/TTXMM1)*TXMWR1
  TXMWM1(J)=TXMWM1(J)+TXMND1-(TAMEC1/TTXMM1)*TXMWR1(J)
  TAMEC1=0.0
END IF
TXMRT1(J)=TIME+TXMNR
TXUR1T=TXUR1T+TXMUR1(J)
TXWP1T=TXWP1T+TXMWP1(J)
TXWM1T=TXWM1T+TXMWM1(J)
TXMWL1=TXWM1T*TXMNMH
```

4

```
TOTAL=TXMND2+TXMUR2(J)
IF(TOTAL.EQ.0.0)GO TO 5
IF(TXMND2.LE.TXMN2)THEN
  TXMWR2=TXMND2
  TXMN2=TXMN2-TXMND2
ELSE
  TXMWR2=TXMN2
  TXMWP2(J)=TXMND2-TXMN2
  TXMN2=0.0
END IF
TTXMM2=TXMWR2*TXMNMNR
IF(TTXMM2.LE.TAMEC2)THEN
  TXMUR2(J)=TXMUR2(J)+TXMWR2
  TAMEC2=TAMEC2-TTXMM2
ELSE
  TXMUR2(J)=TXMUR2(J)+(TAMEC2/TTXMM2)*TXMWR2
  TXMWM2(J)=TXMWM2(J)+TXMND2-(TAMEC2/TTXMM2)*TXMWR2(J)
  TAMEC2=0.0
```

```

END IF
TXMRT2(J)=TIME+TXMNTR
TXUR2T=TXUR2T+TXMUR2(J)
TXWP2T=TXWP2T+TXMWP2(J)
TXWM2T=TXWM2T+TXMWM2(J)
TXMWL2=TXWM2T*TXMNMH

TXMND3=TXMND3+ETXWR1+ETXWR2
TOTAL=TXMND3+TXMUR3(J)
IF(TOTAL.EQ.0.0)GO TO 6
IF(TXMND3.LE.TXMN3)THEN
  TXMWR3=TXMND3
  TXMN3=TXMN3-TXMND3
ELSE
  TXMWR3=TXMN3
  TXMWP3(J)=TXMND3-TXMN3
  TXMN3=0.0
END IF
TTXMM3=TXMWR3*TXMNMH
IF(TTXMM3.LE.TAMEC3)THEN
  TXMUR3(J)=TXMUR3(J)+TXMWR3
  TAMEC3=TAMEC3-TTXMM3
ELSE
  TXMUR3(J)=TXMUR3(J)+(TAMEC3/TTXMM3)*TXMWR3
  TXMWM3(J)=TXMWM3(J)+TXMND3-(TAMEC3/TTXMM3)*TXMWP3(J)
  TAMEC3=0.0
END IF
TXMRT3(J)=TIME+TXMNTR
TXMWL3=TXMWM3(J)*TXMNMH
TXUR3T=TXUR3T+TXMUR3(J)
TXWP3T=TXWP3T+TXMWP3(J)
TXWM3T=TXWM3T+TXMWM3(J)

Tank transfers

TOTAL=TXFRD1+TXFUR1(J)
IF(TOTAL.EQ.0.0)GO TO 7
IF(TXFRD1.LE.TXFR1)THEN
  TXFWR1=TXFRD1
  TXFR1=TXFR1-TXFRD1
ELSE
  TXFWR1=TXFR1
  TXFWP1(J)=TXFRD1-TXFR1
  TXFR1=0.0
END IF
TTXFM1=TXFWR1*TXFMR
IF(TTXFM1.LE.TAMEC1)THEN
  TXFUR1(J)=TXFUR1(J)+TXFWR1
  TAMEC1=TAMEC1-TTXFM1
ELSE

```

5

6

```

TXEUR1(J)=TXEUR1(J)+(TAMEC1/TTXFM1)*TXFWR1
TXFWM1(J)=TXFWM1(J)+TXFRD1-(TAMEC1/TTXFM1)*TXFWR1-TXFWP1(J)
TAMEC1=0.0

```

```

END IF
TXERT1(J)=TIME+TXFTR
TFUR1T=TFUR1T+TXEUR1(J)
TFWP1T=TFWP1T+TXFWP1(J)
TFWM1T=TFWM1T+TXFWM1(J)
TXFWL1=TFWM1T*TXFERMH

```

```

TOTAL=TXFRD2+TXFUR2(J)
IF(TOTAL.EQ.0.0)GO TO 8
IF{TXFRD2.LE.TXFR2}THEN
  TXFWR2=TXFRD2
  TXFR2=TXFR2-TXFRD2
ELSE
  TXFWR2=TXFR2
  TXFWP2(J)=TXFRD2-TXFR2
  TXFR2=0.0

```

```

END IF
TTXFM2=TXFWR2*TXFERMR
IF(TTXFM2.LE.TAMEC2)THEN
  TXFUR2(J)=TXFUR2(J)+TXFWR2
  TAMEC2=TAMEC2-TTXFM2

```

```

ELSE
  TXFUR2(J)=TXFUR2(J)+(TAMEC2/TTXFM2)*TXFWR2
  TXFWM2(J)=TXFWM2(J)+TXFRD2-(TAMEC2/TTXFM2)*TXFWR2-TXFWP2(J)
  TAMEC2=0.0

```

```

END IF
TXERT2(J)=TIME+TXFTR
TFUR2T=TFUR2T+TXFUR2(J)
TFWP2T=TFWP2T+TXFWP2(J)
TFWM2T=TFWM2T+TXFWM2(J)
TXFWL2=TFWM2T*TXFERMH

```

```

TXFRD3=TXFRD3+ETFWR1+ETFWR2
TOTAL=TXFRD3+TXFUR3(J)
IF(TOTAL.EQ.0.0)GO TO 9
IF{TXFRD3.LE.TXFR3}THEN
  TXFWR3=TXFRD3
  TXFR3=TXFR3-TXFRD3
ELSE
  TXFWR3=TXFR3
  TXFWP3(J)=TXFRD3-TXFR3
  TXFR3=0.0

```

```

END IF
TTXFM3=TXFWR3*TXFERMR
IF(TTXFM3.LE.TAMEC3)THEN
  TXFUR3(J)=TXFUR3(J)+TXFWR3

```

7

8

```

TAMEC3=TAMEC3-TTXFM3
ELSE
TXFUR3(J)=TXFUR3(J)+(TAMEC3/TTXFM3)*TXFWR3
TXFWM3(J)=TXFWM3(J)+TXFRD3-(TAMEC3/TTXFM3)*TXFWR3-TXFWRP3(J)
TAMEC3=0.0
END IF
TXFR3(J)=TIME+TXFRTR
TXFUR3T=TXFUR3T+TXFUR3(J)
TXFWRP3T=TXFWRP3T+TXFWRP3(J)
TXFWM3T=TXFWM3T+TXFWM3(J)
TXFWL3=TXFWM3T*TXFERMH

```

Tank track

```

TOTAL=TTRKD1+TTRUR1(J)
IF(TOTAL.EQ.0.0)GO TO 12
IF(TTRKD1.LE.TTRK1)THEN
TTRWR1=TTRKD1
TTRK1=TTRK1-TTRKD1
ELSE
TTRWR1=TTRK1
TTRWP1(J)=TTRKD1-TTRK1
TTRK1=0.0
END IF
TTRM1=TTRWR1*TTRKMR
IF(TTRM1.LE.TAMEC1)THEN
TTRUR1(J)=TTRUR1(J)+TTRWR1
TAMEC1=TAMEC1-TTRM1
ELSE
TTRUR1(J)=TTRUR1(J)+(TAMEC1/TTRM1)*TTRWR1
TTRWM1(J)=TTRWM1(J)+TTRKD1-(TAMEC1/TTRM1)*TTRWR1-TTRWP1(J)
TAMEC1=0.0
END IF
TTRT1(J)=TIME+TTRKTR
TTRUR1T=TTRUR1T+TTRUR1(J)
TTRWP1T=TTRWP1T+TTRWP1(J)
TTRWM1T=TTRWM1T+TTRWM1(J)
TTRWL1=TTRWM1T*TTRKMH
TOTAL=TTRKD2+TTRUR2(J)
IF(TOTAL.EQ.0.0)GO TO 13
IF(TTRKD2.LE.TTRK2)THEN
TTRWR2=TTRKD2
TTRK2=TTRK2-TTRKD2
ELSE
TTRWR2=TTRK2
TTRWP2(J)=TTRKD2-TTRK2
TTRK2=0.0
END IF
TTRM2=TTRWR2*TTRKMR

```

9

12

```

IF( TTRM2. LE. TAMEC2) THEN
  TTRUR2(J)=TTRUR2(J)+TTRWR2
  TAMEC2=TAMEC2-TTTRM2
ELSE
  TTRUR2(J)=TTRUR2(J)+(TAMEC2/TTTRM2)*TTRWR2
  TTRWM2(J)=TTRWM2(J)+TTRKD2-(TAMEC2/TTTRM2)*TTRWR2-TTRWP2(J)
  TAMEC2=0.0
END IF
TTRR2(J)=TIME+TTRKTR
TTRUR2T=TTRUR2T+TTRUR2(J)
TTRWP2T=TTRWP2T+TTRWP2(J)
TTRWM2T=TTRWM2T+TTRWM2(J)
TTRWL2=TTRWM2T*TTRKMH

TTRKD3=TTRKD3+ETTWR1+ETTWR2
TOTAL=TTRKD3+TTRUR3(J)
IF( TOTAL. EQ. 0.0) GO TO 14
IF( TTRKD3. LE. TTRK3) THEN
  TTRWR3=TTRKD3
  TTRK3=TTRK3-TTRKD3
ELSE
  TTRWR3=TTRK3
  TTRWP3(J)=TTRKD3-TTRK3
  TTRK3=0.0
END IF
TTRM3=TTRWR3*TTRKMR
IF( TTRM3. LE. TAMEC3) THEN
  TTRUR3(J)=TTRUR3(J)+TTRWR3
  TAMEC3=TAMEC3-TTTRM3
ELSE
  TTRUR3(J)=TTRUR3(J)+(TAMEC3/TTTRM3)*TTRWR3
  TTRWM3(J)=TTRWM3(J)+TTRKD3-(TAMEC3/TTTRM3)*TTRWR3-TTRWP3(J)
  TAMEC3=0.0
END IF
TTRR3(J)=TIME+TTRKTR
TTRUR3T=TTRUR3T+TTRUR3(J)
TTRWP3T=TTRWP3T+TTRWP3(J)
TTRWM3T=TTRWM3T+TTRWM3(J)
TTRWL3=TTRWM3T*TTRKMH

```

Tank final drives

```

14 TOTAL=TFDRD1+TFDUR1(J)
  IF( TOTAL. EQ. 0.0) GO TO 15
  IF( TFDRD1. LE. TFDR1) THEN
    TFDWR1=TFDRD1
    TFDR1=TFDR1-TFDRD1
  ELSE
    TFDWR1=TFDR1
    TFDWP1(J)=TFDRD1-TFDR1

```

```

TFDR1=0.0
END IF
TTFDM1=TFDWR1*TFDRMR
IF( TTFDM1.LE.TAMEC1) THEN
  TFDUR1(J)=TFDUR1(J)+TFDWR1
  TAMEC1=TAMEC1-TTFDM1
ELSE
  TFDUR1(J)=TFDUR1(J)+(TAMEC1/TTFDM1)*TFDWR1
  TFDWM1(J)=TFDWM1(J)+TFDRD1-(TAMEC1/TTFDM1)*TFDWR1-TFDWPF1(J)
  TAMEC1=0.0
END IF
TFDRT1(J)=TIME+TFDRTR
TDUR1T=TDUR1T+TFDUR1(J)
TDWPF1T=TDWPF1T+TFDWP1(J)
TDWM1T=TDWM1T+TFDWM1(J)
TFDWL1=TDWM1T*TFDRMH

15
TOTAL=TFDRD2+TFDUR2(J)
IF( TOTAL.EQ.0.0) GO TO 16
IF( TFDUR2.LE.TFDR2) THEN
  TFDWR2=TFDRD2
  TFDR2=TFDR2-TFDRD2
ELSE
  TFDWR2=TFDR2
  TFDWPF2(J)=TFDRD2-TFDR2
  TFDR2=0.0
END IF
TTFDM2=TFDWR2*TFDRMR
IF( TTFDM2.LE.TAMEC2) THEN
  TFDUR2(J)=TFDUR2(J)+TFDWR2
  TAMEC2=TAMEC2-TTFDM2
ELSE
  TFDUR2(J)=TFDUR2(J)+(TAMEC2/TTFDM2)*TFDWR2
  TFDWM2(J)=TFDWM2(J)+TFDRD2-(TAMEC2/TTFDM2)*TFDWR2-TFDWPF2(J)
  TAMEC2=0.0
END IF
TFDRT2(J)=TIME+TFDRTR
TDUR2T=TDUR2T+TFDUR2(J)
TDWPF2T=TDWPF2T+TFDWP2(J)
TDWM2T=TDWM2T+TFDWM2(J)
TFDWL2=TDWM2T*TFDRMH

16
TFDRD3=TFDRD3+ETDWR1+ETDWR2
TOTAL=TFDRD3+TFDUR3(J)
IF( TOTAL.EQ.0.0) GO TO 17
IF( TFDUR3.LE.TFDR3) THEN
  TFDWR3=TFDRD3
  TFDR3=TFDR3-TFDRD3
ELSE

```

```

TFDWR3=TFDR3
TFDWP3(J)=TFDRD3-TFDR3
TFDR3=0.0
END IF
TFEDM3=TFDWR3*TFDRMR
IF( TFEDM3.LE.TAMEC3) THEN
  TFDUR3(J)=TFDUR3(J)+TFDWR3
  TAMEC3=TAMEC3-TTFEDM3
ELSE
  TFDUR3(J)=TFDUR3(J)+(TAMEC3/TTFEDM3)*TFDWR3
  TFDWM3(J)=TFDWM3(J)+TFDRD3-(TAMEC3/TTFEDM3)*TFDWR3-TFDWP3(J)
  TAMEC3=0.0
END IF
TEDRT3(J)=TIME+TFDRTR
TDUR3T=TDUR3T+TFDUR3(J)
TDWP3T=TDWP3T+TFDWP3(J)
TDWM3T=TDWM3T+TFDWM3(J)
TFDWL3=TDWM3T*TFDRMH

```

Tank fire control systems

17

```

TOTAL=TFCND1+TECUR1(J)
IF( TOTAL.EQ.0.0) GO TO 18
IF( TFCND1.LE.TECN1) THEN
  TECWR1=TFCND1
  TFCN1=TFCN1-TFCND1
ELSE
  TECWR1=TECN1
  TECWP1(J)=TFCND1-TECN1
  TFCN1=0.0
END IF
TTEFCM1=TECWR1*TECNMR
IF( TTEFCM1.LE.FCMEC1) THEN
  TECUR1(J)=TECUR1(J)+TECWR1
  FCMEC1=FCMEC1-TTEFCM1
ELSE
  TECUR1(J)=TECUR1(J)+(FCMEC1/TTEFCM1)*TECWR1
  TECWM1(J)=TECWM1(J)+TFCND1-(FCMEC1/TTEFCM1)*TECWR1-TFCWP1(J)
  FCMEC1=0.0
END IF
TECRT1(J)=TIME +TECNTR
TCUR1T=TCUR1T+TECUR1(J)
TCWP1T=TCWP1T+TECWP1(J)
TCWM1T=TCWM1T+TECWM1(J)
TECWL1=TCWM1T*TECNMH

```

18

```

TOTAL=TFCND2+TECUR2(J)
IF( TOTAL.EQ.0.0) GO TO 19
IF( TFCND2.LE.TECN2) THEN
  TECWR2=TFCND2

```

```

TFCN2=TFCN2-TFCND2
ELSE
TFCWR2=TFCN2
TFCWP2(J)=TFCND2-TFCN2
TFCN2=0.0
END IF
TTEFCM2=TFCWR2*TFCNMR
IF( TTEFCM2.LE.FCMEC2) THEN
TFCUR2(J)=TFCUR2(J)+TFCWR2
FCMEC2=FCMEC2-TTEFCM2
ELSE
TFCUR2(J)=TFCUR2(J)+(FCMEC2/TTEFCM2)*TFCWR2
TFCWM2(J)=TFCWM2(J)+TFCND2-(FCMEC2/TTEFCM2)*TFCWR2-TFCWP2(J)
FCMEC2=0.0
END IF
TFCRT2(J)=TIME +TFCNTR
TCUR2T=TCUR2T+TFCUR2(J)
TCWP2T=TCWP2T+TFCWP2(J)
TCWM2T=TCWM2T+TFCWM2(J)
TFCWL2=TCWM2T*TFCNMRH

```

19

```

TFCND3=TFCND3+ETCWR1+ETCWR2
TOTAL=TFCND3+TFCUR3(J)
IF( TOTAL.EQ.0.0) GO TO 20
IF( TFCND3.LE.TFCN3) THEN
TFCWR3=TFCND3
TFCN3=TFCN3-TFCND3
ELSE
TFCWR3=TFCN3
TFCWP3(J)=TFCND3-TFCN3
TFCN3=0.0
END IF
TTEFCM3=TFCWR3*TFCNMR
IF( TTEFCM3.LE.FCMEC3) THEN
TFCUR3(J)=TFCUR3(J)+TFCWR3
FCMEC3=FCMEC3-TTEFCM3
ELSE
TFCUR3(J)=TFCUR3(J)+(FCMEC3/TTEFCM3)*TFCWR3
TFCWM3(J)=TFCWM3(J)+TFCND3-(FCMEC3/TTEFCM3)*TFCWR3-TFCWP3(J)
FCMEC3=0.0
END IF
TFCRT3(J)=TIME +TFCNTR
TCUR3T=TCUR3T+TFCUR3(J)
TCWP3T=TCWP3T+TFCWP3(J)
TCWM3T=TCWM3T+TFCWM3(J)
TFCWL3=TCWM3T*TFCNMRH

```

Tank armament systems

20

```

TOTAL=TARMD1+TARUR1(J)
IF(TOTAL.EQ.0.0)GO TO 21
IF(TARMD1.LE.TARM1)THEN
  TARWR1=TARMD1
  TARM1=TARM1-TARMD1
ELSE
  TARWR1=TARM1
  TARWP1(J)=TARMD1-TARM1
  TARM1=0.0
END IF
TTARM1=TARWR1*TARMMR
IF(TTARM1.LE.ARMED1)THEN
  TARUR1(J)=TARUR1(J)+TARWR1
  ARMED1=ARMED1-TTARM1
ELSE
  TARUR1(J)=TARUR1(J)+(ARMED1/TTARM1)*TARWR1
  TARWM1(J)=TARWM1(J)+TARMD1-(ARMED1/TTARM1)*TARWR1-TARWP1(J)
  ARMED1=0.0
END IF
TARRT1(J)=TIME +TARMTR
TAUR1T=TAUR1T+TARUR1(J)
TAWP1T=TAWP1T+TARWP1(J)
TAWM1T=TAWM1T+TARWM1(J)
TARWL1=TAWM1T*TARMMH

```

21

```

TOTAL=TARMD2+TARUR2(J)
IF(TOTAL.EQ.0.0)GO TO 22
IF(TARMD2.LE.TARM2)THEN
  TARWR2=TARMD2
  TARM2=TARM2-TARMD2
ELSE
  TARWR2=TARM2
  TARWP2(J)=TARMD2-TARM2
  TARM2=0.0
END IF
TTARM2=TARWR2*TARMMR
IF(TTARM2.LE.ARMED2)THEN
  TARUR2(J)=TARUR2(J)+TARWR2
  ARMED2=ARMED2-TTARM2
ELSE
  TARUR2(J)=TARUR2(J)+(ARMED2/TTARM2)*TARWR2
  TARWM2(J)=TARWM2(J)+TARMD2-(ARMED2/TTARM2)*TARWR2-TARWP2(J)
  ARMED2=0.0
END IF
TARRT2(J)=TIME +TARMTR
TAUR2T=TAUR2T+TARUR2(J)
TAWP2T=TAWP2T+TARWP2(J)
TAWM2T=TAWM2T+TARWM2(J)
TARWL2=TAWM2T*TARMMH

```

```

22  TARMD3=TARMD3+ETAWR1+ETAWR2
    TOTAL=TARMD3+TARUR3(J)
    IF(TOTAL.EQ.0.0)GO TO 23
    IF{ TARMD3.LE.TARM3 } THEN
        TARWR3=TARMD3
        TARM3=TARM3-TARMD3
    ELSE
        TARWR3=TARM3
        TARWP3(J)=TARMD3-TARM3
        TARM3=0.0
    END IF
    TTARM3=TARWR3*TARMMR
    IF( TTARM3.LE.ARMED3 ) THEN
        TARUR3(J)=TARUR3(J)+TARWR3
        ARMED3=ARMED3-TTARM3
    ELSE
        TARUR3{ J }=TARUR3{ J }+( ARMED3/TTARM3)*TARWR3
        TARWM3{ J }=TARWM3{ J }+TARMD3-( ARMED3/TTARM3)*TARWR3(J)
        ARMED3=0.0
    END IF
    TARRT3( J )=TIME +TARMTR
    TAUR3T=TAUR3T+TARUR3{ J }
    TAWP3T=TAWP3T+TARWP3{ J }
    TAWM3T=TAWM3T+TARWM3{ J }
    TARWL3=TAWM3T*TARMMH

```

Tank electrical systems

```

23  TOTAL=TELED1+TELUR1(J)
    IF(TOTAL.EQ.0.0)GO TO 24
    IF{ TELED1.LE.TELE1 } THEN
        TELWR1=TELED1
        TELE1=TELE1-TELED1
    ELSE
        TELWR1=TELE1
        TELWP1(J)=TELED1-TELE1
        TELE1=0.0
    END IF
    TELM1=TELWR1*TELEMR
    IF( TELM1.LE.ELMEC1 ) THEN
        TELUR1(J)=TELUR1(J)+TELWR1
        ELMEC1=ELMEC1-TTELM1
    ELSE
        TELUR1{ J }=TELUR1{ J }+(ELMEC1/TTELM1)*TELWR1
        TELWM1{ J }=TELWM1{ J }+TELED1-(ELMEC1/TTELM1)*TELWR1-TELWP1(J)
        ELMEC1=0.0
    END IF
    TELRT1( J )=TIME +TELETR

```

```

TLUR1T=TLUR1T+TELUR1(J)
TLWP1T=TLWP1T+TELWP1(J)
TLWM1T=TLWM1T+TELWM1(J)
TELWL1=TLWM1T*TELEMH

24 TOTAL=TELED2+TELUR2(J)
IF(TOTAL.EQ.0.0)GO TO 25
IF(TELED2.LE.TELED2)THEN
  TELWR2=TELED2
  TELE2=TELED2-TELED2
ELSE
  TELWR2=TELE2
  TELWP2(J)=TELED2-TELE2
  TELE2=0.0
END IF
TTELM2=TELWR2*TELEMR
IF(TTELM2.LE.ELMEC2)THEN
  TELUR2(J)=TELUR2(J)+TELWR2
  ELMEC2=ELMEC2-TTELM2
ELSE
  TELUR2(J)=TELUR2(J)+(ELMEC2/TTELM2)*TELWR2
  TELWM2(J)=TELWM2(J)+TELED2-(ELMEC2/TTELM2)*TELWR2-TELWP2(J)
  ELMEC2=0.0
END IF
TELR2T(J)=TIME+TELETR
TLUR2T=TLUR2T+TELUR2(J)
TLWP2T=TLWP2T+TELWP2(J)
TLWM2T=TLWM2T+TELWM2(J)
TELWL2=TLWM2T*TELEMH

25 TELED3=TELED3+ETLWR1+ETLWR2
TOTAL=TELED3+TELUR3(J)
IF(TOTAL.EQ.0.0)GO TO 26
IF(TELED3.LE.TELED3)THEN
  TELWR3=TELED3
  TELE3=TELED3-TELED3
ELSE
  TELWR3=TELE3
  TELWP3(J)=TELED3-TELE3
  TELE3=0.0
END IF
TTELM3=TELWR3*TELEMR
IF(TTELM3.LE.ELMEC3)THEN
  TELUR3(J)=TELUR3(J)+TELWR3
  ELMEC3=ELMEC3-TTELM3
ELSE
  TELUR3(J)=TELUR3(J)+(ELMEC3/TTELM3)*TELWR3
  TELWM3(J)=TELWM3(J)+TELED3-(ELMEC3/TTELM3)*TELWR3-TELWP3(J)
  ELMEC3=0.0
END IF

```

```

TELRT3(J)=TIME +TELETR
TLUR3T=TLUR3T+TELUR3(J)}
TLWP3T=TLWP3T+TELWP3(J)}
TLWM3T=TLWM3T+TELWM3(J)}
TELWL3=TLWM3T*TELEMH

```

6. WORKLOAD COMPUTATIONS

These algorithms calculate the maintenance workload at the two maintenance contact teams and evacuate any repair work which exceeds their capability to return in a given timeframe to the DS maintenance company in the rear.

```

26  TACWL1=TENWL1+TXMWL1+TXFWL1+TFDWL1+TTRWL1
    FCCWL1=TFCWL1
    ARCWL1=TARWL1
    ELCWL1=TELWL1
    TACWL2=TENWL2+TXMWL2+TXFWL2+TFDWL2+TTRWL2
    FCCWL2=TFCWL2
    ARCWL2=TARWL2
    ELCWL2=TELWL2

```

Tank track evacuations

```

IF(TACWL1.LE.TM1AWL)GO TO 40
OVERL=TACWL1-TM1AWL
IF(OVERL.GT.TTRWL1)THEN
  TTETR1(J)=TTWM1T
  TTWM1T=0.0
  TACWL1=TACWL1-TTRWL1
  TTRWL=0.0
ELSE
  TTETR1(J)=OVERL/TTRKMH
  TTWM1T=TTWM1T-TTETR1(J)
  TTRWL1=TTRWL1-OVERL
  TACWL1=TM1AWL
END IF

```

Tank final drive evacuations

```

IF(TACWL1.LE.TM1AWL)GO TO 40
OVERL=TACWL1-TM1AWL
IF(OVERL.GT.TFDWL1)THEN

```

```

TDETR1(J)=TDWMLT
TDWMLT=0.0
TACWL1=TACWL1-TFDWL1
TFDWL1=0.0
ELSE
TDETR1(J)=OVERL/TFDRMH
TDWMLT=TDWMLT-TDETR1(J)
TFDWL1=TFDWL1-OVERL
TACWL1=TM1AWL
END IF

Tank transfer evacuations

IF(TACWL1.LE.TM1AWL)GO TO 40
OVERL=TACWL1-TM1AWL
IF(OVERL.GT.TXFWL1)THEN
TFETR1(J)=TFWMLT
TFWMLT=0.0
TACWL1=TACWL1-TXFWL1
TXFWL1=0.0
ELSE
TFETR1(J)=OVERL/TXFRMH
TFWMLT=TFWMLT-TFETR1(J)
TXFWL1=TXFWL1-OVERL
TACWL1=TM1AWL
END IF

Tank transmission evacuations

IF(TACWL1.LE.TM1AWL)GO TO 40
OVERL=TACWL1-TM1AWL
IF(OVERL.GT.TXMWL1)THEN
TXETR1(J)=TXWMLT
TXWMLT=0.0
TACWL1=TACWL1-TXMWL1
TXMWL1=0.0
ELSE
TXETR1(J)=OVERL/TXMNMH
TXWMLT=TXWMLT-TXETR1(J)
TXMWL1=TXMWL1-OVERL
TACWL1=TM1AWL
END IF

Tank engine evacuations

IF(TACWL1.LE.TM1AWL)GO TO 40
OVERL=TACWL1-TM1AWL
IF(OVERL.GT.TENWL1)THEN
TEETR1(J)=TEWMLT
TEWMLT=0.0

```

```

TACWL1=TACWL1-TENWL1
TENWL1=0.0
ELSE
TEETR1(J)=OVERL/TENGMH
TEWM1T=TEWM1T-TEETR1(J)
TENWL1=TENWL1-OVERL
TACWL1=TM1AWL
END IF

```

Tank fire control system evacuations

```

40 IF(FCCWL1.LE.FM1AWL)GO TO 41
OVERL=FCCWL1-FM1AWL
IF(OVERL.GT.TFCWL1)THEN
TCETR1(J)=TCWM1T
TCWM1T=0.0
FCCWL1=FCCWL1-TFCWL1
TFCWL1=0.0
ELSE
TCETR1(J)=OVERL/TFCNMH
TCWM1T=TCWM1T-TCETR1(J)
TFCWL1=TFCWL1-OVERL
FCCWL1=FM1AWL
END IF

```

Tank armament system evacuations

```

41 IF(ARCWL1.LE.AM1AWL)GO TO 42
OVERL=ARCWL1-AM1AWL
IF(OVERL.GT.TARWL1)THEN
TAETR1(J)=TAWM1T
TAWM1T=0.0
ARCWL1=ARCWL1-TARWL1
TARWL1=0.0
ELSE
TAETR1(J)=OVERL/TARMMH
TAWM1T=TAWM1T-TAETR1(J)
TARWL1=TARWL1-OVERL
ARCWL1=AM1AWL
END IF

```

Tank electrical system evacuations

```

42 IF(ELCWL1.LE.EM1AWL)GO TO 43
OVERL=ELCWL1-EM1AWL
IF(OVERL.GT.TELWL1)THEN
TEETR1(J)=TLWM1T
TLWM1T=0.0
ELCWL1=ELCWL1-TELWL1
TELWL1=0.0

```

```

ELSE
  TLETR1(J)=OVERL/TELEMH
  TLWM1T=TLWM1T-TLETR1(J)
  TELWL1=TELWL1-OVERL
  ELCWL1=EM1AWL
END IF

```

This section of code calculates the evacuated components from the 2nd MST

43

```

IF(TACWL2.LE.TM2AWL)GO TO 45
OVERL=TACWL2-TM2AWL
IF(OVERL.GT.TTRWL2)THEN
  TTETR2(J)=TTWM2T
  TTWM2T=0.0
  TACWL2=TACWL2-TTRWL2
  TTRWL=0.0
ELSE
  TTETR2(J)=OVERL/TTRKMH
  TTWM2T=TTWM2T-TTETR2(J)
  TTRWL2=TTRWL2-OVERL
  TACWL2=TM2AWL
END IF

```

```

IF(TACWL2.LE.TM2AWL)GO TO 45
OVERL=TACWL2-TM2AWL
IF(OVERL.GT.TFDWL2)THEN
  TDETR2(J)=TDWM2T
  TDWM2T=0.0
  TACWL2=TACWL2-TFDWL2
  TFDWL2=0.0
ELSE
  TDETR2(J)=OVERL/TFDRMH
  TDWM2T=TDWM2T-TDETR2(J)
  TFDWL2=TFDWL2-OVERL
  TACWL2=TM2AWL
END IF

```

```

IF(TACWL2.LE.TM2AWL)GO TO 45
OVERL=TACWL2-TM2AWL
IF(OVERL.GT.TXFWL2)THEN
  TFETR2(J)=TFWM2T
  TFWM2T=0.0
  TACWL2=TACWL2-TXFWL2
  TXFWL2=0.0
ELSE
  TFETR2(J)=OVERL/TFERMH
  TFWM2T=TFWM2T-TFETR2(J)
  TXFWL2=TXFWL2-OVERL

```

```

TACWL2=TM2AWL
END IF

IF(TACWL2.LE.TM2AWL)GO TO 45
OVERL=TACWL2-TM2AWL
IF(OVERL.GT.TXMWL2)THEN
  TXETR2(J)=TXWM2T
  TXWM2T=0.0
  TACWL2=TACWL2-TXMWL2
  TXMWL2=0.0
ELSE
  TXETR2(J)=OVERL/TXMNMH
  TXWM2T=TXWM2T-TXETR2(J)
  TXMWL2=TXMWL2-OVERL
  TACWL2=TM2AWL
END IF

IF(TACWL2.LE.TM2AWL)GO TO 45
OVERL=TACWL2-TM2AWL
IF(OVERL.GT.TENWL2)THEN
  TEETR2(J)=TEWM2T
  TEWM2T=0.0
  TACWL2=TACWL2-TENWL2
  TENWL2=0.0
ELSE
  TEETR2(J)=OVERL/TENGMH
  TEWM2T=TEWM2T-TEETR2(J)
  TENWL2=TENWL2-OVERL
  TACWL2=TM2AWL
END IF

45 IF(FCCWL2.LE.FM2AWL)GO TO 46
OVERL=FCCWL2-FM2AWL
IF(OVERL.GT.TFCWL2)THEN
  TCETR2(J)=TCWM2T
  TCWM2T=0.0
  FCCWL2=FCCWL2-TFCWL2
  TFCWL2=0.0
ELSE
  TCETR2(J)=OVERL/TFCNMH
  TCWM2T=TCWM2T-TCETR2(J)
  TFCWL2=TFCWL2-OVERL
  FCCWL2=FM2AWL
END IF

```

```

46 IF(ARCWL2.LE. AM2AWL)GO TO 47
OVERL=ARCWL2-AM2AWL
IF(OVERL.GT. TARWL2) THEN
  TAETR2(J)=TAWM2T
  TAWM2T=0.0
  ARCWL2=ARCWL2-TARWL2
  TARWL2=0.0
ELSE
  TAETR2(J)=OVERL/TARMMH
  TAWM2T=TAWM2T-TAETR2(J)
  TARWL2=TARWL2-OVERL
  ARCWL2=AM2AWL
END IF

```

```

47 IF(ELCWL2.LE. EM2AWL)GO TO 48
OVERL=ELCWL2-EM2AWL
IF(OVERL.GT. TELWL2) THEN
  TLETR2(J)=TLWM2T
  TLWM2T=0.0
  ELCWL2=ELCWL2-TELWL2
  TELWL2=0.0
ELSE
  TLETR2(J)=OVERL/TELEMH
  TLWM2T=TLWM2T-TLETR2(J)
  TELWL2=TELWL2-OVERL
  ELCWL2=EM2AWL
END IF

```

7. EVACUATION TIME ROUTINES

These routines cycle through the evacuation time queues and determine which of the evacuated jobs from the two forward maintenance support teams have arrived at the DS maintenance company.

```

48 IF(J.EQ.1) THEN
GO TO 402
ELSE
M=J-1
END IF

```

```

DO 992 K=1,J
Tank engines arrived
  IF(EVACT1(K).LE.TIME)THEN
    ETWTR1=TEETR1(K)
    ETENT1=ETENT1-TEETR1(K)
    TEETR1(K)=0.0
  ELSE
    END IF
Tank transmissions arrived
  IF(EVACT1(K).LE.TIME)THEN
    ETXWR1=TXETR1(K)
    ETXMT1=ETXMT1-TXETR1(K)
    TXETR1(K)=0.0
  ELSE
    END IF
Tank transfers arrived
  IF(EVACT1(K).LE.TIME)THEN
    ETFWR1=TFETR1(K)
    ETXFT1=ETXFT1-TFETR1(K)
    TFETR1(K)=0.0
  ELSE
    END IF
Tank track arrived
  IF(EVACT1(K).LE.TIME)THEN
    ETWTR1=TTETR1(K)
    ETTRT1=ETTRT1-TTETR1(K)
    TTETR1(K)=0.0
  ELSE
    END IF
Tank final drives arrived
  IF(EVACT1(K).LE.TIME)THEN
    ETDWR1=TDETR1(K)
    ETFDT1=ETFDT1-TDETR1(K)
    TDETR1(K)=0.0
  ELSE
    END IF
Tank fire control systems arrived
  IF(EVACT1(K).LE.TIME)THEN

```

```

ETCWR1=TCETR1(K)
ETECT1=ETECT1-TCETR1(K)
TCETR1(K)=0.0
ELSE
END IF

```

Tank armament systems arrived

```

IF(EVACT1(K).LE.TIME)THEN
ETAWR1=TAETR1(K)
ETART1=ETART1-TAETR1(K)
TAETR1(K)=0.0
ELSE
END IF

```

Tank electrical systems arrived

```

IF(EVACT1(K).LE.TIME)THEN
ETLWR1=TLETR1(K)
ETELT1=ETELT1-TLETR1(K)
TLETR1(K)=0.0
ELSE
END IF

```

The following section of code determines which components have arrived at the DS company from the 2nd MST

```

IF(EVACT2(K).LE.TIME)THEN
ETEWR2=TEETR2(K)
ETENT2=ETENT2-TEETR2(K)
TEETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETXWR2=TXETR2(K)
ETXMT2=ETXMT2-TXETR2(K)
TXETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETFWR2=TFETR2(K)
ETXFT2=ETXFT2-TFETR2(K)
TFETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETWR2=TTETR2(K)
ETTR2=ETTRT2-TETR2(K)
TTETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETDWR2=TDETR2(K)
ETFDT2=ETFDT2-TDETR2(K)
TDETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETCWR2=TCETR2(K)
ETFCT2=ETFCT2-TCETR2(K)
TCETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETAWR2=TAETR2(K)
ETART2=ETART2-TAETR2(K)
TAETR2(K)=0.0
ELSE
END IF

```

```

IF(EVACT2(K).LE.TIME)THEN
ETLWR2=TLETR2(K)
ETELT2=ETELT2-TLETR2(K)
TLETR2(K)=0.0
ELSE
END IF

```

992 CONTINUE

8. OUTPUT GENERATION

The following statements format the output as given in Chapter 5.

[illegible]

```

925 FORMAT(1X,'FDR',4X,F6.2,2X,F6.2,2X,F6.2,3X,F6.2,4X,F6.2,2,3X,F6.2)
WRITE(6,926)TARM2,T,TAUR2T,TAWP2T,TAWM2T,TARRR2(J),TARM2
926 FORMAT(1X)ARM,4X,F6.2,2X,F6.2,2X,F6.2,3X,F6.2,4X,F6.2,2,3X,F6.2)
WRITE(6,927)TELED2,TLUR2T,TLWP2T,TLWM2T,TELR2(J),TELE2
927 FORMAT(1X,'ELE',4X,F6.2,2X,F6.2,2X,F6.2,3X,F6.2,4X,F6.2,2,3X,F6.2)

```

PRINT, - - - - -
PRINT, - - - - -
PRINT, - - - - -
PRINT, - - - - -

PRINT	'	DS MAINTENANCE COMPANY TANK STATUS REPORT AS OF' , TIME
PRINT	'	-----
PRINT	'	SYSYEM NEW UNDER WAITING WAITING REPAIRS PARTS'
PRINT	'	DAMAGES REPAIR PARTS MECHANICS COMPLETED ON HAND,
PRINT	'	-----

940	WRITE(6,940)TENG3,TEUR3T,TEWP3T,TEWM3T,TENRR3(J),TENG3
941	WRITE(6,941)TXMND3,TXUR3T,TXWP3T,TXWM3T,TXMRR3(J),TXMN3
942	WRITE(6,942)TXFRD3,TEUR3T,TEWP3T,TEWM3T,TXFRR3(J),TXFR3
943	WRITE(6,943)TRRKD3,TTUR3T,TTWP3T,TTWM3T,TTRRR3(J),TRRK3
944	WRITE(6,944)TECND3,TCUR3T,TCWP3T,TCWM3T,TECRR3(J),TECN3
945	WRITE(6,945)TEPRD3,TDUR3T,TDWP3T,TDWM3T,TEPRR3(J),TEPR3
946	WRITE(6,946)TARM3,TAUR3T,TAWP3T,TAWM3T,TARRR3(J),TARM3
947	WRITE(6,947)TELED3,TLUR3T,TLWP3T,TLWM3T,TELEDR3(J),TELE3

[illegible]

```

50 WRITE(6,50) ETENT1, ETENT2, ETWR1, ETWR2
   FORMAT(1X, ENC, 3X, F6.2, 7X, F6.2, 8X, F6.2, 9X, F6.2)
51 WRITE(6,51) ETXMT1, ETXMT2, ETXWR1, ETXWR2
   FORMAT(1X, XMN, 3X, F6.2, 7X, F6.2, 8X, F6.2, 9X, F6.2)
52 WRITE(6,52) ETXFT1, ETXFT2, ETFWR1, ETFWR2
   FORMAT(1X, XFR, 3X, F6.2, 7X, F6.2, 8X, F6.2, 9X, F6.2)
53 WRITE(6,53) ETEDT1, ETEDT2, ETDWR1, ETDWR2
   FORMAT(1X, EDR, 3X, F6.2, 7X, F6.2, 8X, F6.2, 9X, F6.2)
WRITE(6,54) ETTRT1, ETTRT2, ETTWR1, ETTWR2

```


APPENDIX B

ALGORITHM VARIABLES

This appendix lists and explains the algorithm variables utilized in the computer program and this thesis.

1. ALGORITHM VARIABLES

The letters and numbers of these algorithm variables relate directly to the function they are supposed to represent. As an example the first variable listed, TENWP, stands for /Tank/Engine/Waiting Parts/. The numbers listed with these variable names in the program listing represent one of the three maintenance elements of the simulation. The numbers one and two represent the two maintenance support teams and the number three represents the DS maintenance company.

1. TENWP: The number of tanks damaged waiting for an engine
2. TXMWP: The number of tanks damaged waiting for a transmission
3. TXFWP: The number of tanks damaged waiting for a transfer
4. TTRWP: The number of tanks damaged waiting for track
5. TECWP: The number of tanks damaged waiting for a fire control system
6. TARWP: The number of tanks damaged waiting for an armament system

7. TELWP: The number of tanks damaged waiting for an electrical system
8. TENUR: The number of tanks being repaired for an engine
9. TXMUR: The number of tanks being repaired for a transmission
10. TXFUR: The number of tanks being repaired for a transfer
11. TTRUR: The number of tanks being repaired for track
12. TFDUR: The number of tanks being repaired for a final drive
13. TFCUR: The number of tanks being repaired for a fire control system
14. TARUR: The number of tanks being repaired for an armament system
15. TELUR: The number of tanks being repaired for an electrical system
16. TENRR: The time when tanks damaged for an engine will be repaired and returned
17. TXMRR: The time when tanks damaged for a transmission will be repaired and returned
18. TXFRR: The time when tanks damaged for a transfer will be repaired and returned
19. TTRRR: the time when tanks damaged for track will be repaired and returned
20. TFDRR: the time when tanks damaged for final drive will be repaired and returned
21. TFCRR: the time when tanks damaged for a fire control system will be repaired and returned
22. TARRR: the time when tanks damaged for an armament system will be repaired and returned
23. TELRR: the time when tanks damaged for an electrical system will be repaired and returned
24. TENWM: the number of tanks being repaired for an engine
25. TXMWM: the number of tanks being repaired for a transmission that are waiting for mechanics
26. TXFWM: the number of tanks being repaired for a transfer that are waiting for mechanics
27. TTRWM: the number of tanks being repaired for track that are waiting for mechanics
28. TFDWM: the number of tanks being repaired for final drives that are waiting for mechanics
29. TFCWM: the number of tanks being repaired for a fire control system that are waiting for mechanics

30. TARWM: the number of tanks being repaired for an armament system that are waiting for mechanics
31. TELWM: the number of tanks being repaired for an electrical system that are waiting for mechanics
32. TENRT: The time when tanks damaged for an engine will be completed
33. TXMRT: The time when tanks damaged for a transmission will be completed
34. TXFRT: The time when tanks damaged for a transfer will be completed
35. TTRRT: the time when tanks damaged for track will be completed
36. TFDRT: the time when tanks damaged for final drive will be completed
37. TFCRT: the time when tanks damaged for a fire control system will be completed
38. TARRT: the time when tanks damaged for an armament system will be completed
39. TELRT: the time when tanks damaged for an electrical system will be completed
40. TENG: tank engines on-hand
41. TXMN: tank transmissions on-hand
42. TXFR: tank transfers on-hand
43. TFDR: tank final drives on-hand
44. TTRK: tank track on-hand
45. TFCN: tank fire control systems on-hand
46. TARM: tank armament systems on-hand
47. TELE: tank electrical systems on-hand
48. TENGD: tank engines damaged
49. TXMND: tank transmissions damaged
50. TXFRD: tank transfers damaged
51. TFDRD: tank final drives damaged
52. TTRKD: tank track damaged
53. TFCND: tank fire control systems damaged
54. TARMD: tank armament systems damaged
55. TELED: tank electrical systems damaged
56. TTENM: total tank engine mechanics required
57. TTXMM: total tank transmission mechanics required
58. TTXFM: total tank transfer mechanics required
59. TTFDm: total tank final drive mechanics required

- 60. TTTRM: total tank track mechanics required
- 61. TTARM: total tank armament mechanics required
- 62. TTFCM: total tank fire control mechanics required
- 63. TTELM: total tank electrical mechanics required
- 64. TEETR: tank engine repairs evacuated to the rear
- 65. TXETR: tank transmission repairs evacuated to the rear
- 66. TFETR: tank transfer repairs evacuated to the rear
- 67. TDETR: tank final drive repairs evacuated to the rear
- 68. TTETR: tank track repairs evacuated to the rear
- 69. TAETR: tank armament repairs evacuated to the rear
- 70. TCETR: tank fire control repairs evacuated to the rear
- 71. TLETR: tank electrical repairs evacuated to the rear
- 72. TAMEC: tracked vehicle mechanic
- 73. ARMEC: armament mechanic
- 74. FCMEC: fire control mechanic
- 75. ELMEC: electrical mechanic
- 76. TEUR1T: total tank engines under repair at MST 1
- 77. TXUR1T: total tank transmissions under repair at MST 1
- 78. TFUR1T: total tank transfers under repair at MST 1
- 79. TDUR1T: total tank final drives under repair at MST 1
- 80. TTUR1T: total tank track under repair at MST 1
- 81. TAUR1T: total tank armament systems under repair at MST 1
- 82. TCUR1T: total tank fire control systems under repair at MST 1
- 83. TLUR1T: total tank electrical systems under repair at MST 1
- 84. TACWL: tracked mechanic current workload
- 85. TM1AWL: tracked mechanic allowable workload
- 86. ARCWL: armament mechanic current workload
- 87. AR1AWL: armament mechanic allowable workload
- 88. FCCWL: fire control mechanic current workload
- 89. FC1AWL: fire control mechanic allowable workload
- 90. ELCWL: electrical mechanic current workload
- 91. EL1AWL: electrical mechanic allowable workload

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